Michio Kaku on the Future • Making Laws for Outer Space

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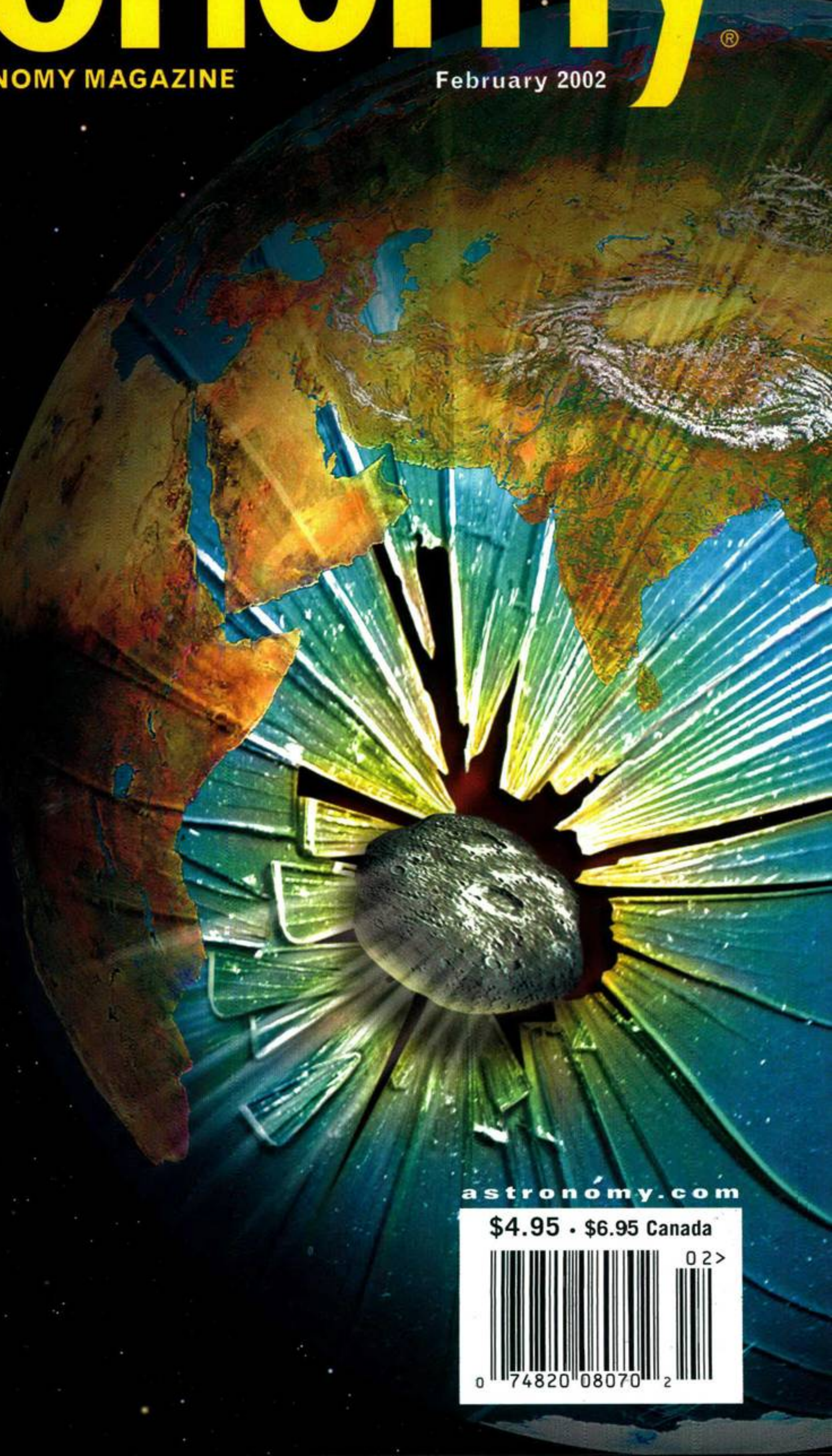
February 2002



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Right-to-left: *Meade 8", 10", and 12" LX200GPS Schmidt-Cassegrain telescopes. Manufactured under U.S. Patent No. 6,304,376; other patents pending in the U.S.A. and worldwide.*

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Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

Precision GPS Alignment: Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

All LX200GPS models include the Zero Image-Shift Microfocuser as standard equipment.

Revolutionary new rear-cell systems designed for the advanced visual observer, astrophotographer and CCD imager — systems that enable new levels of precision in focusing in all applications and in image centering on CCD chips:

Primary Mirror Lock: Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used in conjunction with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

Zero Image-Shift Microfocuser: Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast and is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope's manual focus knob.

Autostar II: The new Autostar II control system provided with LX200GPS models includes all of the features that made previous LX200 models the largest-selling serious telescopes in the world. In addition, Autostar II includes an expanded 3.5 Megabyte memory, with a greatly enlarged database of more than 125,000 celestial objects, a database that is immediately accessible on the Autostar II display. A partial listing of the Autostar II database:

Library	No. of Objects
New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28, 484
SAO and Hipparcos Star Catalogs	31,090
Messier Catalog (M)	110
Caldwell Catalog	109
Named Objects	227
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645

SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS — Each complete telescope includes 8", 10", or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5 Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 9-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 125,000-object onboard celestial software library; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords are available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

INTRODUCTORY PRICES
MEADE LX200GPS SCHMIDT-CASSEGRAIN TELESCOPES

8" LX200GPS	**$2495**
10" LX200GPS	**2995**
12" LX200GPS	**3995**
7" LX200GPS Maksutov-Cassegrain	**2995**

Packing & shipping charges in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

	Meade LX200GPS	Competing 11" GPS*
GPS Receiver	16-channel	12-channel
Magnetic declination compensation	yes	no
True-level electronic sensor	yes	no
Primary mirror lock	yes	no
Zero image-shift microfocuser	yes	no
Maximum slew speed	8°/second	3°/second
Memory	3.5-Meg flash	1.0-Meg flash
GO TO pointing precision	2-arcmins	unstated
High-precision pointing mode	yes; permits GO TO pointing precision within 1-arcmin	no
Permanent Periodic Error Correction	yes, both axes	one axis only; second axis unprogrammable
Object database	125,000 objects	"40,000+"
Encoder resolution	0.14 arcsecs	0.26 arcsecs
Internal battery compartments for battery powering	yes; batteries located internal to fork arms	no
RS-232 software download	yes; object libraries and software downloads available	not currently available on factory website**
Tracking calibration	not required	recommended after changes in telescope position or load

*Based on sample and instruction manual received in 7/01. ** As of 11/5/01.

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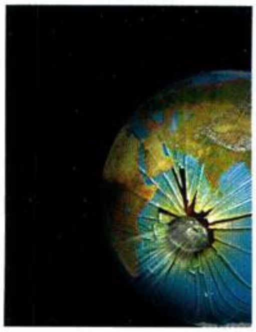

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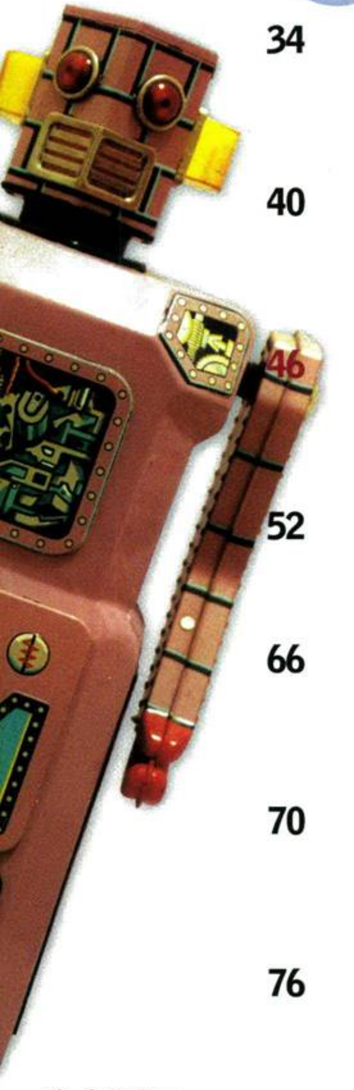

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Given a million years, an advanced civilization might be able to harness the power of a star — or galaxy — to accomplish extraordinary things. *Michio Kaku*

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From quarrels over mineral rights on other worlds to pickpockets aboard a space station, the heavens cry out for the creation of space laws. *David Tenenbaum*

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Although the odds are remote that Earth will be hit by a large piece of cosmic flotsam or jetsam, the consequences would be devastating. *David Morrison*

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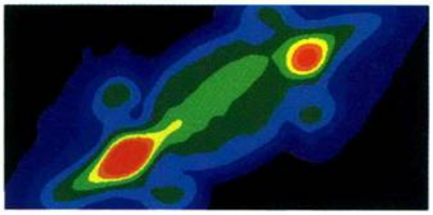

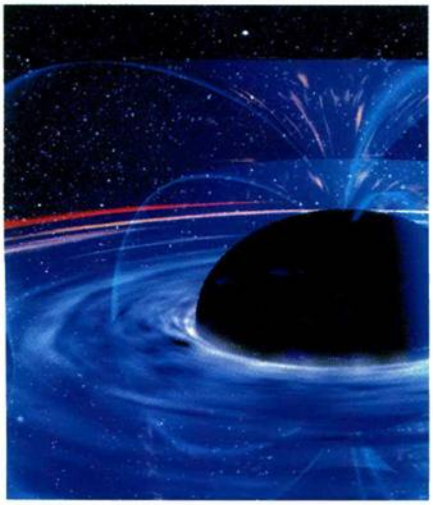

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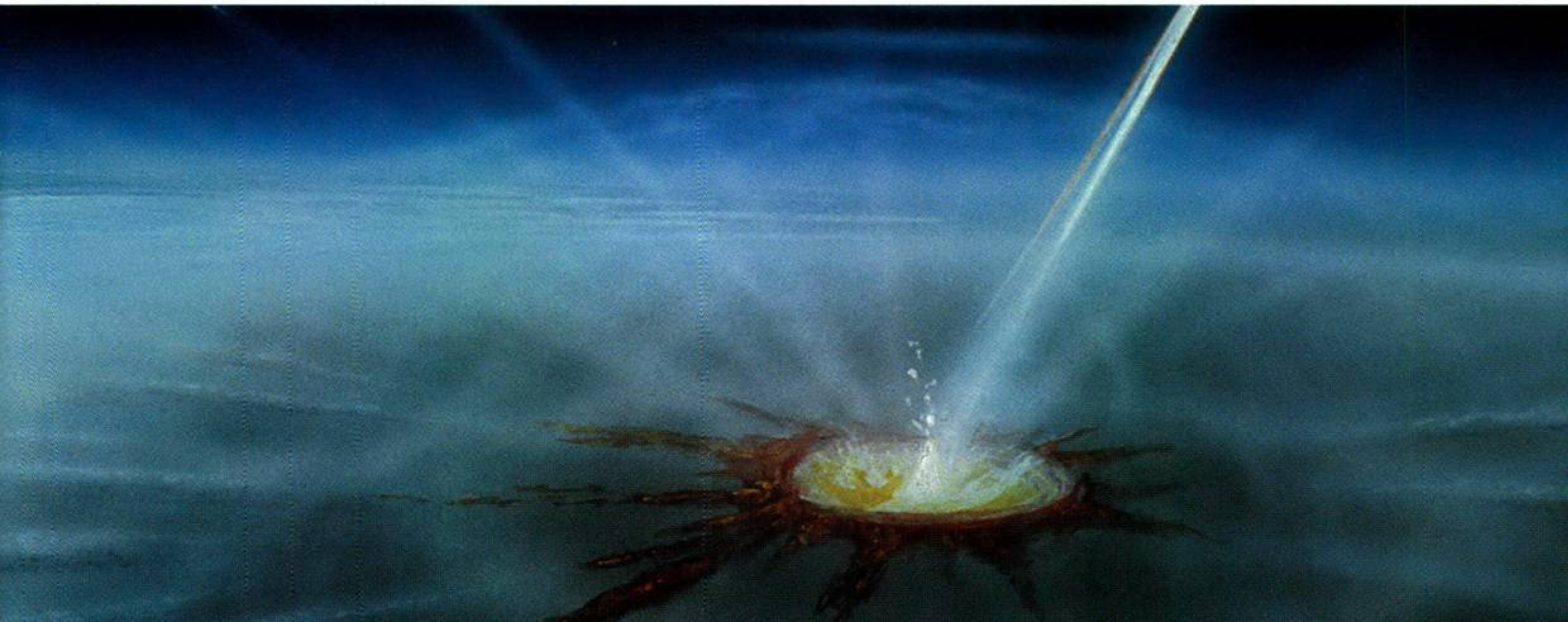

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

A Murder in Outer Space?

If, as some psychologists suggest, our astronauts risk death by murder during a long, stressful trip to Mars, who will provide them with at least the protection of law? What if an international crew pilots such a trip? Under whose jurisdiction would a murder fall?

When we imagine ourselves traveling about in space, hundreds of possible events might require the rule of law. But what will that be? How will we prove fault when two spaceships collide? Can we colonize a planet by planting a national flag on its surface? Can we establish boundaries on tiny Pluto?

Even our remote-controlled workers need to be programmed with a code of behavior. What speed limit will be tolerated for a rover on Mars? Can robots unplug one another in self-defense?

Gary Baseman

Traffic accidents in space, as the illustration above suggests, might someday become a legal issue. See story on page 46.

To answer some of these questions we present an investigative report on space law (see page 46) as one piece of our special issue on the future. David Tenenbaum, a staff writer for the *Why Files*, gives us the scoop on what's been done, what's being considered (and by whom), and what we may expect as universal space law.

Since we as yet have no Federation Command to tell us the rules, we must fumble about on our own. Tenenbaum has interviewed interested lawyers all over the country and he brings us both their knowledge and their speculative ruminations on the subject.

Anyone who has ever watched *Star Trek*, or for that matter *Star Wars*, knows the kind of complications that develop when several civilizations at different levels of development come into contact with one another. The rule of law is perhaps one of the simplest problems. Power, technology, and physical and behavioral styles could collide between worlds if other intelligent species are even a bit like earthlings.

In another part of our special issue on the future, Michio Kaku interprets and analyzes many aspects of advanced civilizations. He reminds us that Earth has not made it yet to Level 1 in his ranking (see page 42).

And finally David Morrison, renowned asteroid expert, explores our chances of being put out of business by an asteroid (see page 54).

Come along and join us on a ride into the future.

Astronomy

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Shown: Meade 8" f/4 LXD55 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System

MEADE LXD55 SCHMIDT-NEWTONIAN TELESCOPES

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6" LXD55 Schmidt-Newtonian	**$599**
8" LXD55 Schmidt-Newtonian	**729**
10" LXD55 Schmidt-Newtonian	**879**

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95. Prices shown are suggested U.S. national mail-order retail prices.

SPECIFICATIONS: 6", 8", and 10" LXD55-Series Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; all-metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

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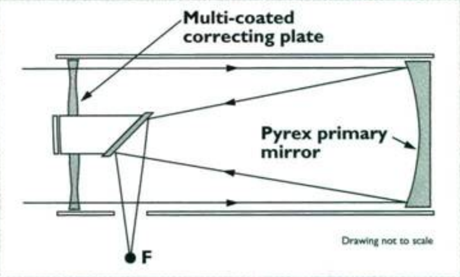
Every Meade LXD55-Series Schmidt-Newtonian telescope includes this listing of standard equipment:

Schmidt-Newtonian optical systems: Manufactured entirely at the Meade Irvine facility, LXD55 diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Combined with fast f/4 (8", 10") or f/5 (6") optics, the standard-equipment Super Plössl 26mm eyepiece yields an actual field in excess of 1.3°, for brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser optical resolution. The optics are mounted in machined aluminum cells fitted to white-enameled metal tubes; each tube accepts the giant Meade rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces.



The Meade Schmidt-Newtonian Optical System.

LXD55 Equatorial Mount: Designed by Meade engineers and manufactured of machined aluminum for high-performance photo-visual observing, the new Meade LXD55 mounting moves effortlessly across the skies in either tracking or automatic GO TO modes. Included is an illuminated polar viewfinder for quick, precise polar alignment.

All LXD55 telescopes include an illuminated polar alignment finder as standard equipment.

Autostar Dual-Axis Electronic Control System: A revelation of advanced electronic and software design, the exclusive patent-pending Meade Autostar system, included as standard equipment with every LXD55 telescope, permits an amazing range of capabilities never before offered on telescopes in this price and aperture class:

Automatic GO TO capability at 4.5°/second on both axes simultaneously, to 30,223 database objects, including:

> 13,235 deep-sky objects — galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs.
>
> 16,888 stars sorted by name, SAO catalog numbers, double and variable stars.
>
> 50 objects in the Solar System; 8 major planets from Mercury to Pluto; the Moon; 26 asteroids; 15 comets.
>
> 50 Earth satellites; 200 memory locations for user-defined objects.

Automatic GO TO capability to *any* object of known R.A. and Declination.

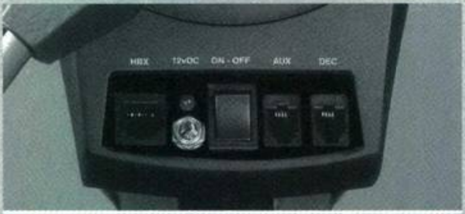
Nine selectable slew and slow-motion speeds: 4.5°, 3°, and 1.5°/sec, 128x, 64x, 16x, 8x, 2x, and 1x sidereal.

Automatic sidereal-rate tracking in R.A. keeps objects precisely centered in the field.

Control of the telescope through your PC and full upgradability over the Internet, using the RS-232 serial interface. (Requires optional #505 Connector Set.)

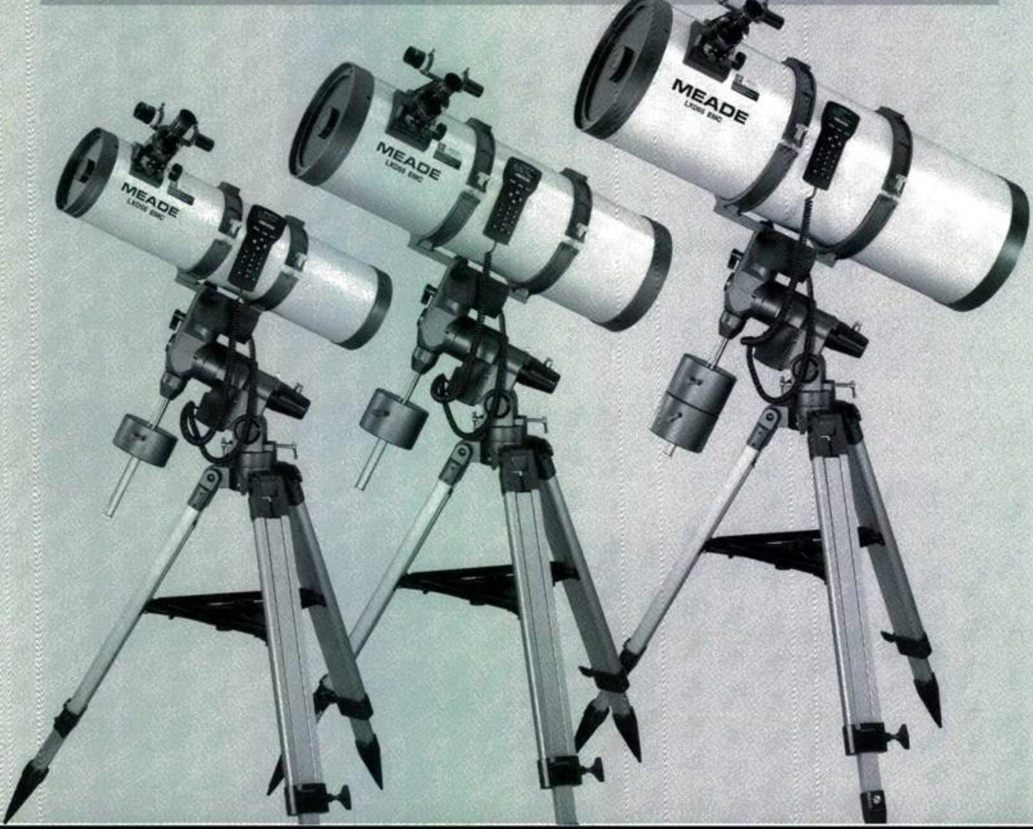
Battery Pack (12vDC): Included with each LXD55 telescope; rests on the telescope's accessory shelf and plugs into the control panel. The battery pack accepts eight (user-supplied) D-cell batteries, which power the telescope for more than 40 hours.

Astrophotography and CCD imaging: Armed with their fast photographic speeds, Meade LXD55 Schmidt-Newtonians are ideally suited for deep-space astrophotography and CCD imaging at the telescope's prime focus.



The LXD55 control panel is located below the upper bearing of the polar axis.

Below, left to right: **Meade 6" f/5, 8" f/4, and 10" f/4 LXD55 Schmidt-Newtonian telescopes.** Each telescope is shipped complete with all equipment shown.



Meade LXD55 Schmidt-Newtonians open up the skies to images and capabilities previously unavailable in telescopes of their aperture and price level. Consider what a Meade LXD55 telescope can do for your observing program:

6" LXD55 – Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope moves effortlessly and automatically from major planet to asteroid to galaxy to nebula at 4.5°/second, placing every object in the center of the telescopic field. Study fine fault lines on the Moon, structural detail in Jupiter's cloud belts and Red Spot, the Cassini division in Saturn's rings, and much more.

8" LXD55 – With 78% more light-gathering power than the 6" model, the 8" LXD55 roughly triples the number of observable objects in deep-space and resolves extremely fine planetary detail as well: Jupiter's cloud belts are seen as a web of intricate discontinuities; transits and shadow transits of Jupiter's main satellites are observable; six of Saturn's satellites may be seen in revolution about the planet. Deep-space phenomena take on new character with the larger 8" aperture, as Autostar moves the telescope automatically from one spectacular object to the next. CCD images at the telescope's prime f/4 focus show a new level of resolution and detail after only a few minutes' exposure.

10" LXD55 – A quantum leap in image brightness and resolution, the 10" LXD55 provides for a lifetime of serious study in deep-space or within the Solar System. Use Autostar to take an automatic tour, on any given evening, of, say, the 200 brightest diffuse nebulae, spiral galaxies, and globular star clusters. Or, with Autostar's pushbutton electronic slow-motion controls, scan the surface of the Moon at high magnification. Let Autostar locate and center in the field the outer planets Uranus and Neptune, now visible as finite-sized orbs, or Pluto, at the telescope's very limit of observability. It is an uncommon observer who might outgrow the capabilities of the Meade 10" LXD55.

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32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
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Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA: 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times *to less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with **any** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

MEADE
FLIP-MIRROR SYSTEM
MEADE
PICTOR

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces.

$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-10; or for visual applications with 1.25" or 2" eyepieces.

249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)

15.00 (3.86)

#644

#647

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk.......... **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP.... **99**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

CCD f/3.3 CCD FOCAL REDUCER

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

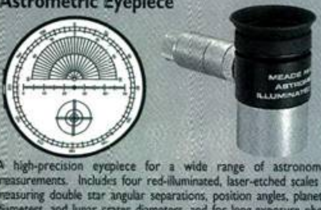
$34.95 (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photoguiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:
99.95 (8.58)

#776 Case for ETX-105EC:
99.95 (8.58)

#775 for ETX-125EC:
149.95 (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70.... **19.95**
#673 for ETX-90....... **24.95**
#675 for ETX-105...... **27.95**
#678 for ETX-125...... **29.95**

Advanced Field Tripod for ETX-125

#887: Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

Tripod Adapter for ETX-125

Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications.

#889 Adapter:
$69.95 (7.70)

ETX® Deluxe Field Tripod

#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag (shown) with pocket for accessories.**

$199.95 (10.00)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:
$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:
$119.95 (6.85)

ELECTRONIC CONTROLLER
MEADE

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

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Orders & Information: 416-787-4581.

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Orders & Information: 416-783-4140.

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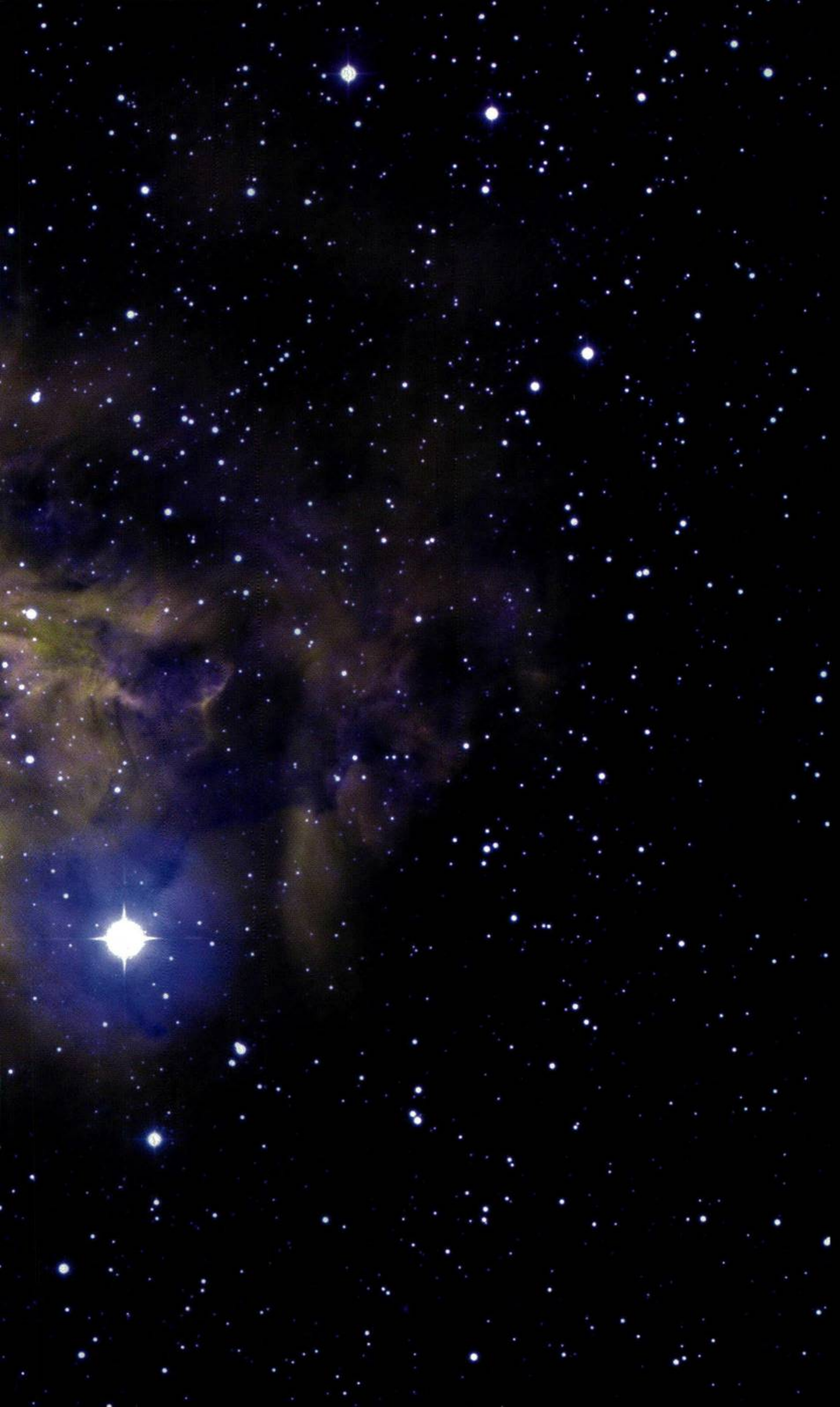


sky Gem

Auriga's Interstellar Inferno

Wrapped in a luminescent blanket of nebular material, AE Aurigae (IC 405, the Flaming Star Nebula) earns its trademark moniker, as light from hydrogen (yellow), oxygen (violet), and sulfur (blue) conspire to create this false-color image captured with the NSF 0.9-meter telescope at Kitt Peak National Observatory, in Arizona.

NOAO/AURA/NSF/T. Rector/B. Wolpa

Planetaria of the Past

I agree that the slides and lasers used in modern-day planetarium shows ("The Planetarium Revolution," October 2001) constitute a spectacular experience compared to the old "arrow on the dome" presentations of days past. But nowadays, does anyone take astronomy home after the show is over?

When I was young, the Adler Planetarium offered a star show that changed every month. A live person guided us through trips around the sky as it would appear that night, telling us what we should try to observe from our backyards. The tour of the evening sky would be followed by another topic of the month, which was always fascinating. As a young person, I was always impressed with the person who knew so much about astronomy; we could even stay and ask questions. These shows didn't have the sound effects of today's presentations, but they gave me a life-long love of astronomy. When we left, we went home looking forward to finding what we had seen on the planetarium dome that day. We went home with a piece of the program. I don't know if that can be said about the glorified slide show we see today. — *Art Maurer, Crete, Illinois*

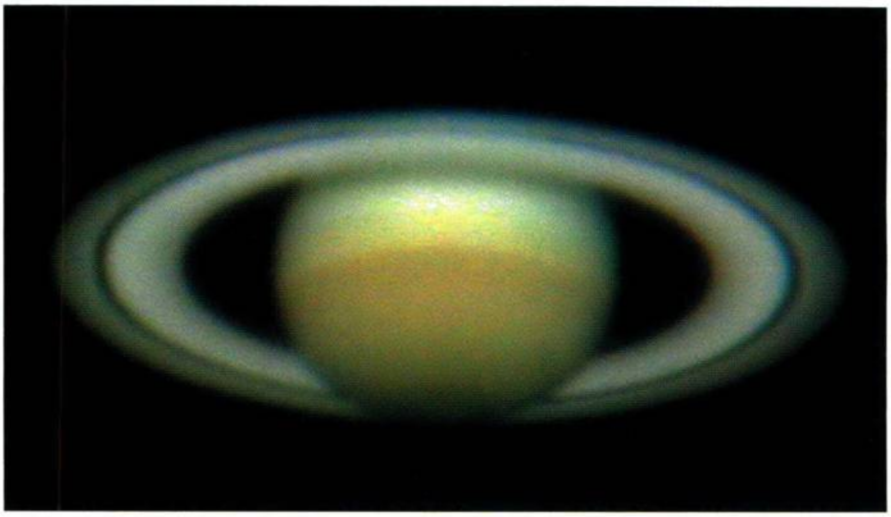
Pick one, please

I have noticed some inconsistencies in your magazine. In the October 2001 issue, two versions of the plural form of "planetarium" appear in "The Planetarium Revolution." On page 80, you use "planetariums," while on other pages, you use "planetaria." Either form is correct, but please stay consistent. — *Tom Reesor, Conway, South Carolina*

Accelerating universe?

In "Celebrating the Galactic Millennium" (November 2001), author Greg Laughlin states that the solar system takes 100 million years to complete one full galactic circuit, and therefore, we are in our 46th such revolution. But until now, I believe the figures have favored more than 200 million years for a single rotation, putting us in the 23rd revolution. Is there new information now, or more acceleration? — *Ted Wolfe, Naples, Florida*

Actually, neither — the mistake's on us. You are correct; the current accepted value for the orbit of the solar system around the galactic center is approximately 230 million years. The statement stemmed from an article entitled "The Galactic Millennium," published by the Astronomical Society of the Pacific and written by Paul Hodge of the University of Washington. Hodge states that "the length of the galactic year is very close to 100 million years." Laughlin used this figure as a basis for our story. But according to the author, the figure of 230 million years is indeed correct and should have been the one cited. We apologize for the error. — Astronomy *editors*



You don't always have to wait for nightfall to spot magnificent Saturn.

Allen Hwang

Planet feat

After reading Charles E. Scovil's letter ("Talking Back," August 2001), I was surprised to learn how many planets can be seen in the daytime with the proper equipment. Prior to this, I believed that only Venus could be seen before nightfall. But by using the moon as a guide, I was able to see both Saturn and Jupiter when the moon passed by them, at 9 A.M. on September 10, 2001, and 10 A.M. on September 12. I used a pair of 7x50 binoculars to accomplish this feat. I can't wait to see more daytime planets. Thanks for the challenge! — *Mark Swaim, Winston-Salem, North Carolina*

Amazing views

I was amazed to discover that photographs of Earth taken from miles high in space ("Seeing Through an Unblinking Eye," December 2001) are just as breathtaking as images of space produced from our planet. I recommend that you include more IKONOS satellite photographs in future issues. — *Joe Daudish, Westchester, Illinois*

A beautiful image of San Diego appears on page 51 of the December 2001 issue. The caption reads that the shot includes the Embarcadero Marina and Park. But I believe the image features the San Diego Convention Center and the Hyatt hotel along the

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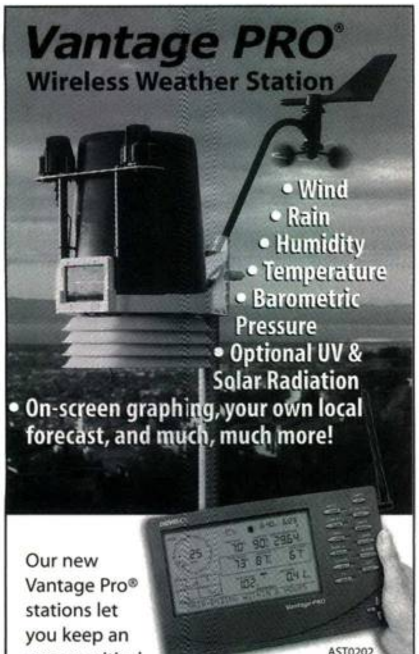

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Learning the stars

As a commerce graduate, I have no background in physics or math. But I have been an amateur astronomer for 11 years now, with *Astronomy* as my teacher. Thanks for all the great information. — *Harshal Raje, Pune, India*

Astrology in *Astronomy*?

On page 128 of the December 2001 issue, the constellation in the "Ultimate Exposure" photograph is referred to as Scorpio. This is its astrological name; the astronomical term is "Scorpius." — *Mike Van Ronzelen, Salem, Oregon*

Corrections

The November 2001 "Sky Show" should have stated that the Leonid meteor shower takes place on the morning of November 19th for observers from Australia through Japan, which is after the event for North American viewers. We apologize for this error. — *Astronomy* editors

In "Listening for E.T." (December 2001), the Arecibo telescope operator in the photo on page 61 was mistakenly identified as Gerson Ortiz. His name is Pedro Torres, Jr. Our apologies to Mr. Torres. — *Astronomy* editors

Photographer Seth Shostak's name was misspelled on page 58 of the December 2001 issue. Our apologies to Mr. Shostak. — *Astronomy* editors

The Mars cover image of the December 2001 issue was mistakenly credited to NASA/JPL. The credit should have read: Centre for Astrophysics and Supercomputing/Swinburne University/P.Bourke. — *Astronomy* editors A

Astronomy invites you to talk back. Send letters to Astronomy *Talking Back, P.O. Box 1612, Waukesha, WI 53187; e-mail to talking@astronomy.com. Letters may be edited for space and clarity. Please include your city, state, and country with all correspondence. If you want to talk back to us, please visit our website, http://www.astronomy.com.*

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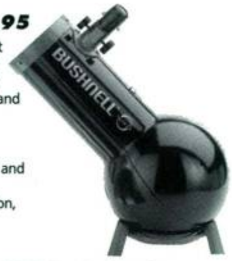

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Search for Earth-like Planets Narrows

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Although astronomers may lack the athletic grace of a long-distance runner, they are no less adept at breaking barriers and opening floodgates. In the six years since the discovery of the first extrasolar planets orbiting sunlike stars, nearly 80 more have been found.

And now in the months since the first system resembling our own turned up (see "A Planetary System Like Our Own?" AstroNews, October 2001), astronomers have detected three more planets that wouldn't seem too out-of-place in our solar system. All three revolve around their parent stars in nearly circular orbits at distances comparable to those of Earth and Mars from the sun.

"Most of the planetary systems we've found have looked like very distant relatives of the solar system — there's no family likeness at all," says Steve Vogt of Lick Observatory in California. "Now we're starting to see something like second cousins and, in a few years, we could be finding brothers or sisters." Vogt belongs to the team of astronomers from the United States, United Kingdom, Belgium, and Australia that announced eight new planets this past October, including the three in circular orbits.

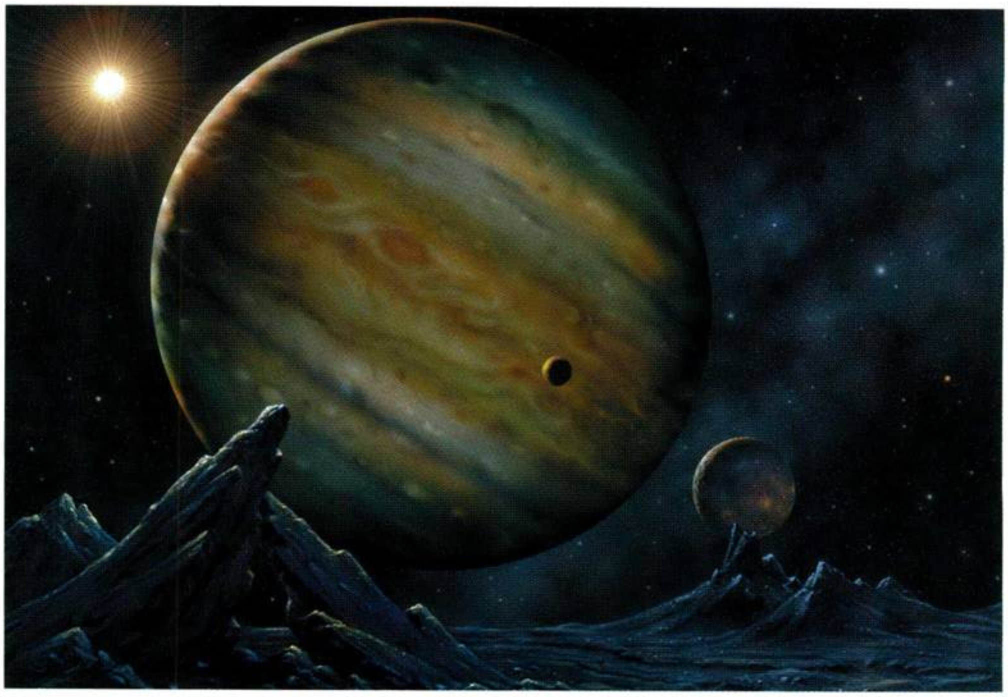
The first of the three planets orbits HD 114783, an 8th-magnitude star located 67 light-years from Earth in Virgo. Its planet has a minimum mass of 0.99 Jupiter and orbits the star at a distance of 1.20 astronomical units. (One astronomical unit, or AU, is the average distance between the sun and Earth — about 93 million miles.) That would place it between Earth and Mars in our solar system.

The second planet belongs to the 7th-magnitude star HD 23079, which lies in Reticulum at a distance of 113 light-years. This planet is the heavyweight of the bunch, with a minimum mass of 2.54 Jupiters, and circles its parent star at a distance of 1.48 AU (slightly less than the size of Mars's orbit). The final planet has a minimum mass of 0.81 Jupiter and lies 1.69 AU from HD 4208, an 8th-magnitude star in Sculptor some 107 light-years away.

Nearly all of the known extrasolar planets — including the five other planets announced in October — either lie within shouting distance of their parent star, closer than about 0.1 AU, or follow highly elongated paths at average distances ranging from approximately 0.2 AU to more than 3 AU.

The new results are the latest from the international collaboration searching for extrasolar planets around the 1,200 nearest stars with the 10-meter Keck Telescope in Hawaii, the 3-meter Shane Telescope at Lick Observatory, and the 3.9-meter Anglo-Australian Telescope in New South Wales, Australia.

"These discoveries strengthen the statistics we are accumulating for such planets," says Hugh Jones of Liverpool John Moores University, the U.K. team leader. The team's long-term goal is to detect analogs to our solar system — planets roughly the size of Jupiter in Jupiter-like orbits. That will help astronomers assess whether planetary systems like ours are common or rare in the galaxy. — RICHARD TALCOTT



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With a nearly circular orbit around HD 23079, this familiar-looking planet brings the possibility of Earth-like planets closer to home.

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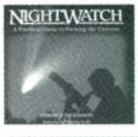

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SHARED TECHNOLOGY

Astronomers Swap Secrets

Although it's often difficult to understand what astronomers and geneticists really do behind closed observatory or laboratory doors, you can rest assured that it's more than simply gawking at faint, fuzzy smudges in the sky or torturing furry little animals for their DNA. As a matter of fact, today more than ever, we know that scientific endeavors regularly yield useful and practical technological advances. What's more, in the last few months, twin tales of collaboration and shared technology between astronomers and geneticists have underscored the potential of pure scientific research to affect our cyber-marinated lives.

A recent technology swap between astronomers and geneticists could lead to better satellite orbits, as well as medical breakthroughs.

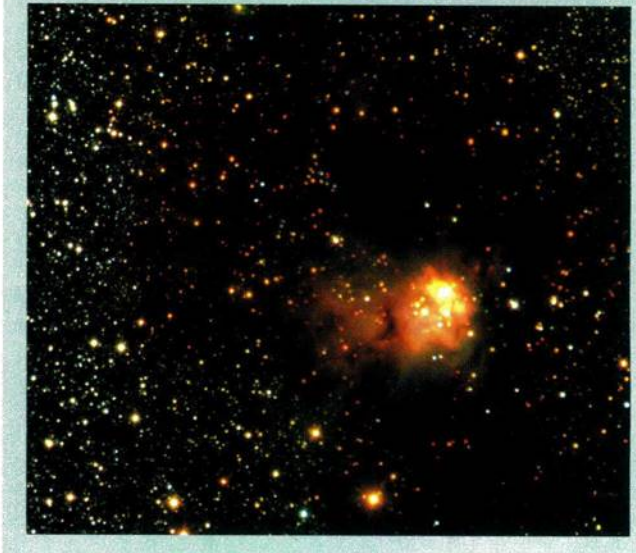
NASA

In two independent (yet symbolically significant) events, computer codes designed to model the evolutionary concept of natural selection and software constructed to process the digital deluge of astronomical data from the Hubble Space Telescope (HST) have recently been swapped between astronomers and gene researchers.

Purdue University engineers, led by William Crossley of Purdue's school of Aeronautics and Astronautics and the Center for Satellite Engineering, employed "genetic algorithms" to construct a new, more efficient method for deploying and tracking low-altitude satellites used for wireless communications and military applications.

Meanwhile, Rockville, Maryland-based Celera Genomics Group recently licensed the rights to NASA's Operational Pipeline Unified Systems (OPUS) software, maintained by the Space Telescope Science Institute (STScI) in Baltimore.

NEW TECHNOLOGY TELESCOPE


ESO/NTT

INFANT STARS BURST FORTH in the rich complex of gas and dust designated RCW 108, in the southern constellation Ara. This wide-field infrared image represents one of the deepest observations yet into a star-forming region. It was made with the 3.6-meter New Technology Telescope at La Silla, Chile, fitted with SOFI, a special infrared camera. The bright nebula IRAS 16362–4845 (center) floats deep inside a dense cloud of dust, whose edges are visible against the background stars. Not surprisingly, stars within the cloud appear redder than those on the outside.

For years, satellite engineers have attempted to improve low-altitude communications and surveillance satellite systems. So far the challenge has centered on clusters of three or more satellites, called constellations, and their ability to maintain contact with ground antennae for long periods of time. At present, satellites orbiting several hundred miles above Earth's surface lose contact with ground bases at least four times daily, constituting a total diurnal loss of about six hours.

Crossley and his colleagues report new findings that promise to reduce satellite communication blackouts by about two hours per day. Their research, published in the July/September issue of the *Journal of Astronautical Sciences*, uses computer algorithms based on Charles Darwin's concept of natural selection to choose the best orbital configuration of satellite constellations. The team fed hundreds of thousands of parameter combinations, including spacing between satellites, their heading, and height above Earth's surface, into their supercomputers. By allowing only the "best performing" solutions to survive, the algorithms

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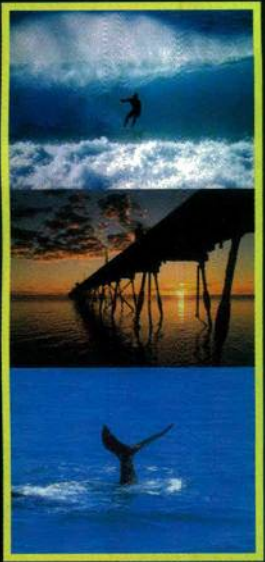

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continue to selectively iterate, yielding progressively better results.

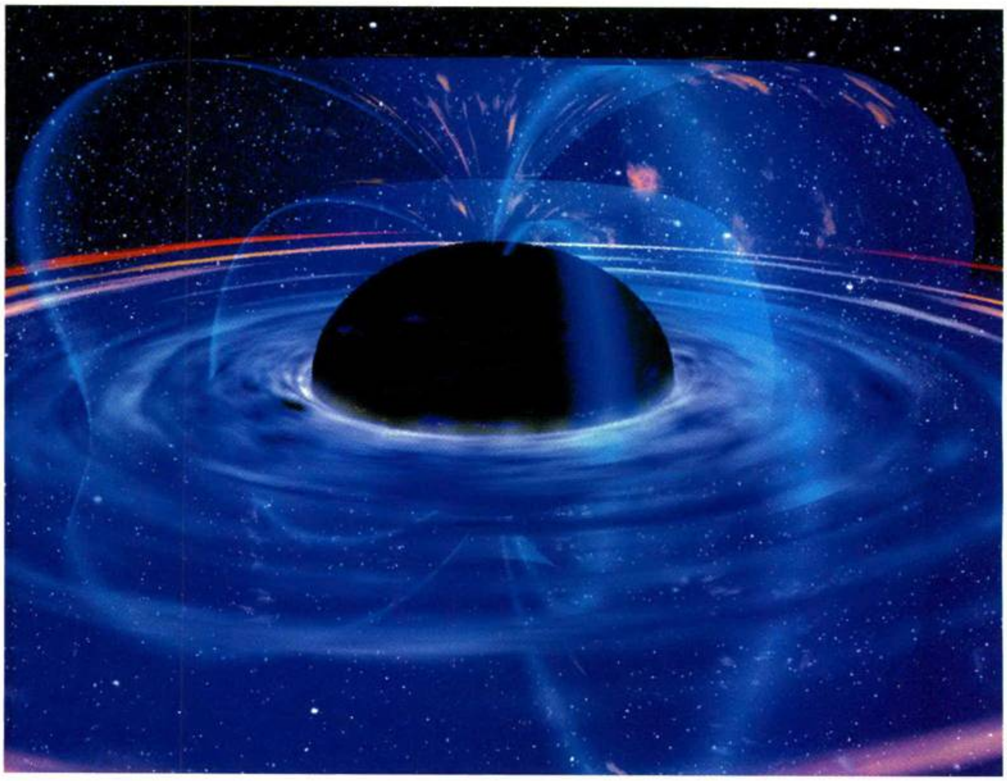
The team was surprised to find that the best combination of orbital parameters was one that they hadn't really considered before. In all previous experiments, satellites were placed equidistant from one another. It turns out this need not be so. In fact, they found that the winning combination involves spacing two satellites very far apart and bringing in the third satellite very close to the rear of the second.

Celera Genomics, who recently completed the world's first assembled and annotated mouse genome, aims to use NASA's OPUS software in order to reduce the drain on their software engineering resources caused by the enormous volume of data gathered in genomics research. They feel that the recent licensing agreement with NASA will allow them to significantly reduce the time it takes to complete complex genomics projects, enabling a speedier delivery of potential benefits to the public sector.

— W. B. SCHOMAKER

BLACK HOLES

Black Hole Bites More Than It Can Chew



NASA

Slamming on the brakes: Energy can escape from rotating black holes when strong magnetic fields act to slow the spin.

▶ Black holes are notorious gluttons. They gobble up all matter and radiation that drift anywhere near their gravitational reach. But now, for the first time, astronomers have found a monstrous black hole at the core of a distant galaxy that can't stomach everything it swallows. It seems that this finicky supermassive black hole, 100 million light-years away at the center of the spiral galaxy MCG-6-30-15, is regurgitating some of its most recent feast in a blast of high-energy x rays.

An international team of astronomers, led by Jörn Wilms of the Eberhard-Karls University in Tübingen, Germany, has been keeping a close eye on MCG-6-30-15's odd behavior with the European Space Agency's XMM-Newton x-ray observatory. The team's latest results, published in the *Monthly Notices of the Royal Astronomical Society*, may finally help astronomers understand how energy can escape from some black holes.

XMM-Newton's sophisticated, high-resolution x-ray cameras allowed the team to discover the luminous x-ray glow from a fountain of super-hot gas coming from the inside edges of an accretion disk surrounding the black hole. The spectroscopic characteristics of the material help the astronomers identify it as iron. The team also found that the iron displays unusually broad emission features.

They are so broad, in fact, that the emissions must be powered by something more than just gravitational collapse of matter falling into the black hole. According to team member Mitchell Begelman of the University of Colorado, an additional power source must be at work to boost the luminosity of the gas to its observed intensity.

"It's like a rubber ball that you bounce on the ground," says Wilms. "You know the surface composition and can guess how and when the ball will come back. But here the ball returns much faster, as if there were a spring where it bounced. For our black hole, this means that something else is powering up the iron atoms, which glow in x rays."

Wilms's team is looking at the possibility that the peculiar phenomenon observed in the core of MCG-6-30-15 qualifies as supporting evidence for a 25-year-old theory originally posited by Roger Blandford, from Caltech, and Roman Znajek, then at Cambridge University in England.

According to the so-called Blandford-Znajek theory, rotational energy can be extracted from a spinning black hole as it is braked by magnetic fields. And, according to the unyielding laws of energy conservation, this energy is transferred to surrounding

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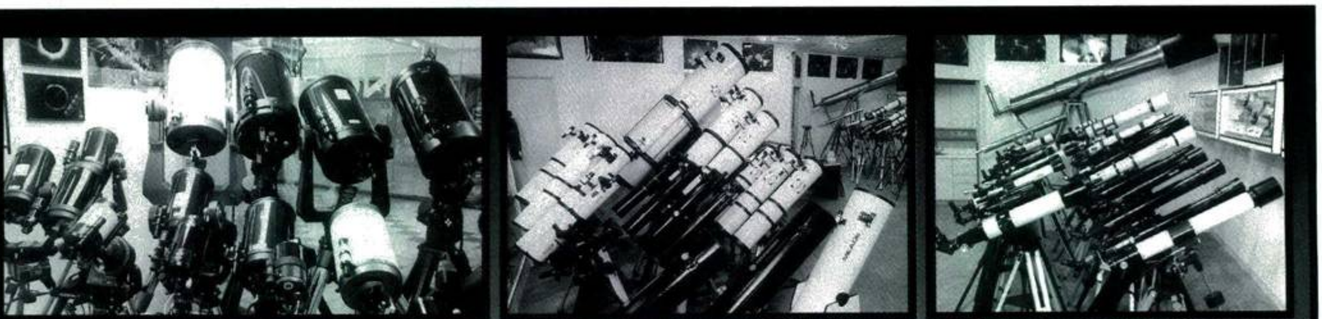

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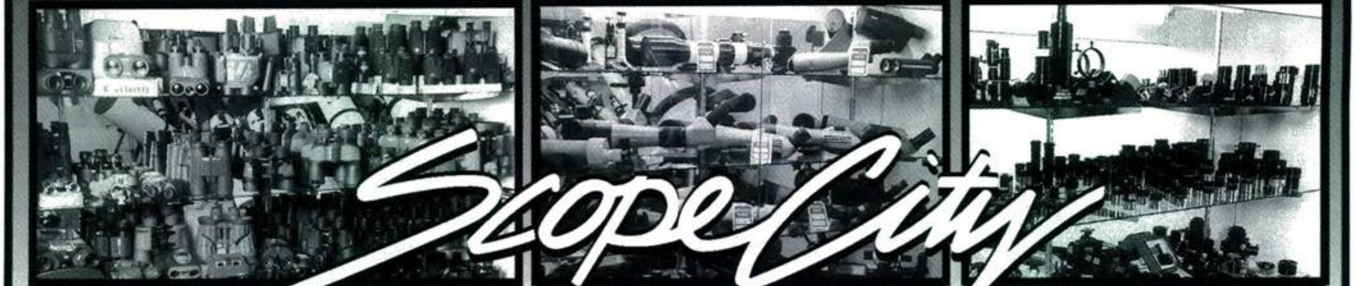

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media (in this case, the inner edge of the black hole's accretion disk). It may then escape along streaming particle jets, flowing perpendicular from the disk.

"Never before have we seen energy extracted from black holes. We always see energy going in, not out," says team member Christopher Reynolds of the University of Maryland. — Paul Morledge

SPACE PHYSICS

Synchronous Aurorae Dazzle Astronomers

▶ For the first time, scientists have captured simultaneous auroral displays at opposite ends of Earth, confirming the long-held theory that aurorae in the northern and southern hemispheres are nearly mirror images of each other.

On October 22, NASA's Polar spacecraft's Visible Imaging System (VIS) captured both the aurora borealis and aurora australis (northern and southern lights) dancing around Earth's polar regions, expanding and brightening in almost perfect sync.

"This is the first time that we have seen both auroral ovals simultaneously with such clarity," says Nicola Fox, science operations manager for the Polar spacecraft at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "With these images, we have the ability to see the dynamics of conjugate aurorae."

Aurorae appear when fast-moving particles trapped in Earth's magnetic field slam into the gases of Earth's upper atmosphere. These electrons and protons can only move along the invisible magnetic field lines, which connect to Earth near the North and South poles. Space weather events energize the magnetic field, sending the particles to both ends of the field lines and creating auroral displays.

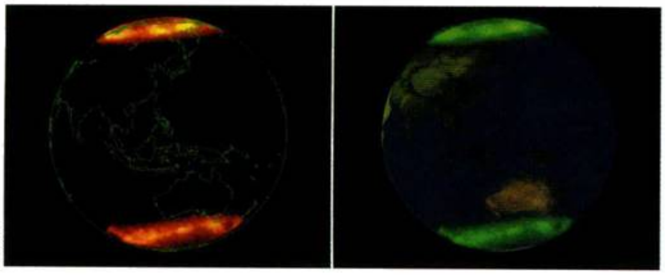
The first recorded sighting of conjugate aurorae took place on September 16, 1770, when the crew of the HMS *Endeavour* spotted auroral activity in the South Pacific on the same night that the northern lights were documented in China. But for centuries, scientists lacked the technology to discover whether conjugate aurorae actually mirrored each other.

Finally, researchers have found their answer. "For the first time, the northern and southern auroral ovals were observed simultaneously with enough resolution to confirm that the northern and southern aurorae are mirror images of each other on a global scale," explains John Sigwarth, a space physicist at the University of Iowa who helped design the VIS cameras.

"Further analysis of these images should help us determine if all of the auroral features are exactly mirrored down to the finest detail," adds Sigwarth.

Preliminary studies have led researchers to believe that while the aurorae copy each other on broad scales, some fine-scale features may not match. — Elesa Janke

New images from NASA's Polar spacecraft establish the connection between aurorae north and south.



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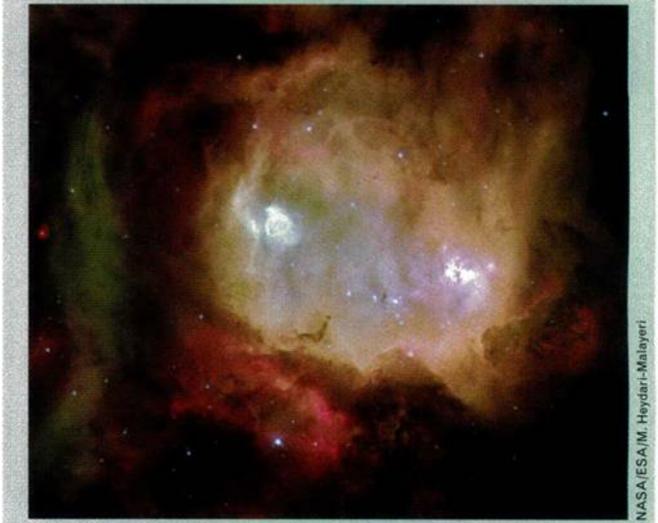

NASA/ESA/M. Heydari-Malayeri

THE GHOST HEAD NEBULA in Dorado glows eerily in this new Hubble Space Telescope image, like a mask painted with light on the sky. The unusual object, designated NGC 2080 and lying just south of the famous nebula 30 Doradus, is well known as one of the prominent star-forming bubbles in the Large Magellanic Cloud. The nebula's light comes from glowing hydrogen and oxygen; red and blue colors emanate from hydrogen gas energized by nearby stars. The green filament at left beams softly from doubly-ionized oxygen, made to glow from the winds of a star just outside the frame. The stark white portions of the nebula at center glow with all three emissions, surrounding a cluster of hot, young stars that is excavating a dish-like shape in the cloud.

GALILEO MISSION

Galileo Samples Unnamed Volcano's Plume

▶ The hard-working Galileo spacecraft surprised scientists yet again when an August 6, 2001 flyby of Io, Jupiter's innermost major moon, revealed another new volcano. Instead of capturing more views of the volcano Tvashtar, as anticipated, Galileo caught images

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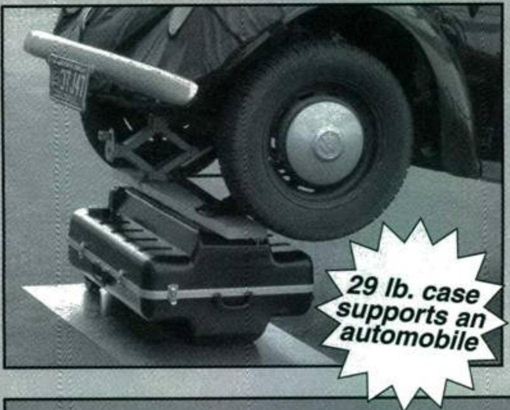
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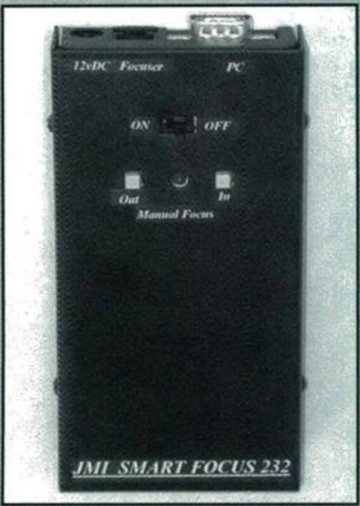
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and eruption particles from a different, unnamed volcano 370 miles (600 kilometers) away.

"We've had wonderful images and other remote sensing of the volcanoes on Io before, but we've never caught the hot breath from one of them until now," says Louis Frank, of the University of Iowa and principal investigator for Galileo's plasma instrumentation. Frank says the particles — sulfur dioxide "snowflakes" detected as Galileo dropped to 120 miles (194 km) above the surface — reached the spacecraft within a few minutes of leaving Io. They comprise the freshest particles ever sampled by Galileo.

The plumes from the unexpected volcano rose at least 300 miles (500 km) above Io — about 10 percent higher than any other measured eruption, according to Galileo imaging team member Alfred McEwen of the University of Arizona.

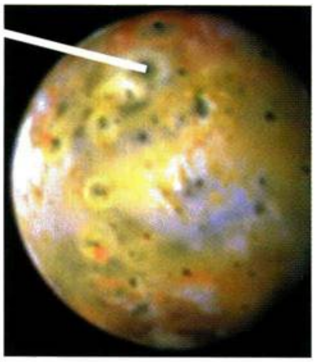
The fallback around the new volcano's source shows up as a bright white ring on the images. This new material overlies the red-ring plume deposit that encircles the Tvashtar volcano to the north.

JPL volcanologist Rosaly Lopes says that Galileo's infrared mapping instrument pinpointed the eruption site as an entirely new hot spot, one that took scientists by surprise. No previous evidence of volcanism existed at those coordinates (41°N, 133°W).

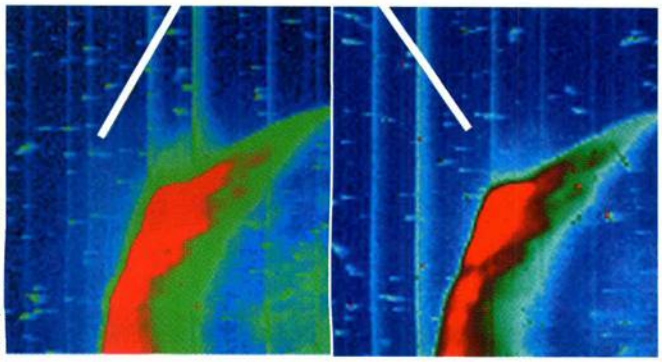
Although Galileo's main transmitting antennae is disabled — the spacecraft uses a secondary antennae to send information instead — the hardy spacecraft has survived more than three times the radiation exposure it was designed to withstand. Engineers have extended Galileo's original two-year mission three times to take advantage of its workhorse capacity. Galileo makes its sixth and final pass over Io in January 2002.

Like Galileo, "Io just keeps amazing everyone," says Eilene Theilig, Galileo project manager at NASA's Jet Propulsion Laboratory in Pasadena, California.

— Carol Ryback



An unexpected volcanic plume on Io's surface (left) rises more than 300 miles above the jovian moon's surface (shown in profile below).



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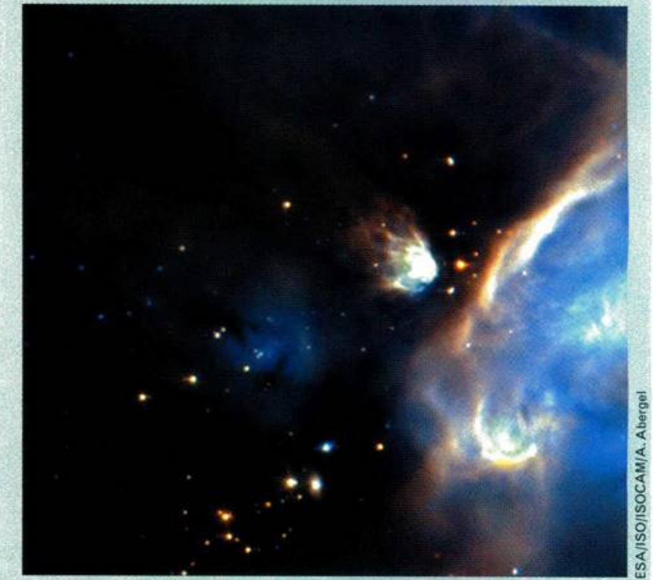
INFRARED SPACE OBSERVATORY



ESA/ISO/ISOCAM/A. Abergel

A REFUGE FOR STELLAR UNDERACHIEVERS lies among the newborn stars of Rho Ophiuchi. Using observations from the decommissioned Infrared Space Observatory, a team led by Lennart Nordh of Stockholm Observatory has found 30 brown dwarfs in the star-forming nebula 540 light-years away. With masses just 5 to 8 percent of our sun's, these "failed stars" in Rho Ophiuchi do not have the bulk to sustain the nuclear fusion that causes normal stars to shine. This attribute makes brown dwarfs difficult to spot, but the 30 newfound objects are young — about a million years old — allowing them to glow slightly brighter than their older relatives.

STAR FORMATION

Toxic Cloud Poised for Starbirth

▶ A team of Dutch and German astronomers recently revealed that a bipolar-jet-wielding protostellar dust cloud called GL 2592 — looming 3,000 light-years away and more than a thousand times larger than the solar system — is chock full of a poisonous, colorless, bitter-almond-smelling compound called hydrogen cyanide (HCN).

Though high doses of HCN are lethal to humans, the compound is apparently crucial to the life-giving star formation process, particularly for stars possessing more than ten times the mass of the sun. But the relative paucity of newly-forming, high-mass stars has unfortunately stymied astronomers from gaining a complete understanding of massive star formation.

Massive stars are rare, *short lived*, and, *therefore*, difficult to study. By allow-

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ing a closer glimpse of the earliest stages of massive star formation, however, astronomers hope that this latest discovery of a caustic cache of HCN may finally enable them to properly characterize the genesis of young, massive stars.

"Detecting large amounts of hydrogen cyanide toward the [center] of a massive protostar means that it has already started to warm up," explains the team's leader, Annemieke Boonman of Leiden University in the Netherlands. "From this information, we can determine the degree of evolution, and therefore the age, of the [proto]star."

The evolution of massive, star-forming clouds can be traced by the presence of complex molecules like HCN. As these clouds are initially quite cool (– 250° Celsius), they don't present an environment conducive to sustaining complex molecules. But as the clouds warm and approach room temperature, complex molecules can form in the cloud cores, heralding the unmistakable and irreversible onset of massive star formation.

Previous Infrared Space Observatory (ISO) investigations signaled the presence of HCN in GL 2591. But due to ISO's poor resolving capabilities, astronomers couldn't rule out the possibility that HCN was forming in localized hot spots such as bipolar outflow jets.

With new data from the 15-meter James Clerk Maxwell telescope atop Mauna Kea in Hawaii, the Dutch-German team was able to rule out the possibility that the HCN was forming in outflows or shock regions. Moreover, the latest observations of GL 2591 opened the door for the team's interpretation that the HCN has formed around the central region of the cloud because the cloud rests on the cusp of entering the "hot core" precursor phase of massive star formation.

Boonman and his team predict that the budding protostar at the center of GL 2591 is 10,000 to 100,000 years old. They also believe that a ten-solar-mass star will emerge from its dusty shroud within about 100,000 years. — W. B. S.

Astronomers employed the poison-sniffing, 15-meter James Clerk Maxwell Telescope to detect hydrogen cyanide 3,000 light-years away.

JCMT

Heavenly Gifts from MIT

A group of 40 middle school finalists and their teachers recently received the honor of a lifetime at last fall's Discovery Young Scientist Challenge in Washington, D.C. — their very own asteroid. MIT's Lincoln Laboratory awarded each competitor with a certificate acknowledging the official transfer of his or her name to a piece of vagabond space debris. And just like that, the students joined the ranks of celebrities, like Frank Zappa, Ella Fitzgerald, and Vincent Van Gogh, who all have namesake asteroids. Lincoln Laboratory director David Briggs says the laboratory staff hopes to encourage excellence in science education in middle and secondary schools by awarding finalists in future contests with similar honors. Scientists working with the Lincoln Near-Earth Asteroid Research (LINEAR) program have discovered thousands of near-Earth asteroids and minor planets since 1998.

Sex in Space

According to the latest studies of gravity's effects on fertilization and conception, near-weightless environments could profoundly influence the reproductive processes of future human spacefarers, as well as their plant and animal cargo. Working with sea urchin sperm, a team of biologists led by Joseph Tash, a NASA researcher with the University of Kansas Medical Center, recently discovered that changes in gravity can significantly alter a species' ability to reproduce. The team found that sperm cells exhibit increased mobility in the near-weightless environs encountered during space shuttle missions, but displayed less vigor when subjected to the increased gravity of Earth-bound laboratory centrifuges.

Astronomy

Made in the EU

When the European Space Agency's far-infrared space observatory (Herschel) is launched from an Ariane 5 rocket in 2007, NASA officials will be cheering — from the sidelines, that is. America's space agency put in a competitive bid to supply a giant 3.5-meter carbon-fiber-based space mirror for Herschel. But a recent decision to go with a competing silicon carbide design gives the lucrative mirror contract to Astrium SAS in Toulouse, France, instead. The move ensures that Herschel will become an entirely European endeavor. Because Herschel's 3.5-meter mirror is too large to cut from a single piece of silicon carbide, the 8-inch-thick, 530-pound primary will be manufactured from 12 individual petals, securing it a place in history as the world's first segmented space mirror. Once operational, Herschel will reach back 13 billion years to detect the infrared glow of the first generation of stars and galaxies.

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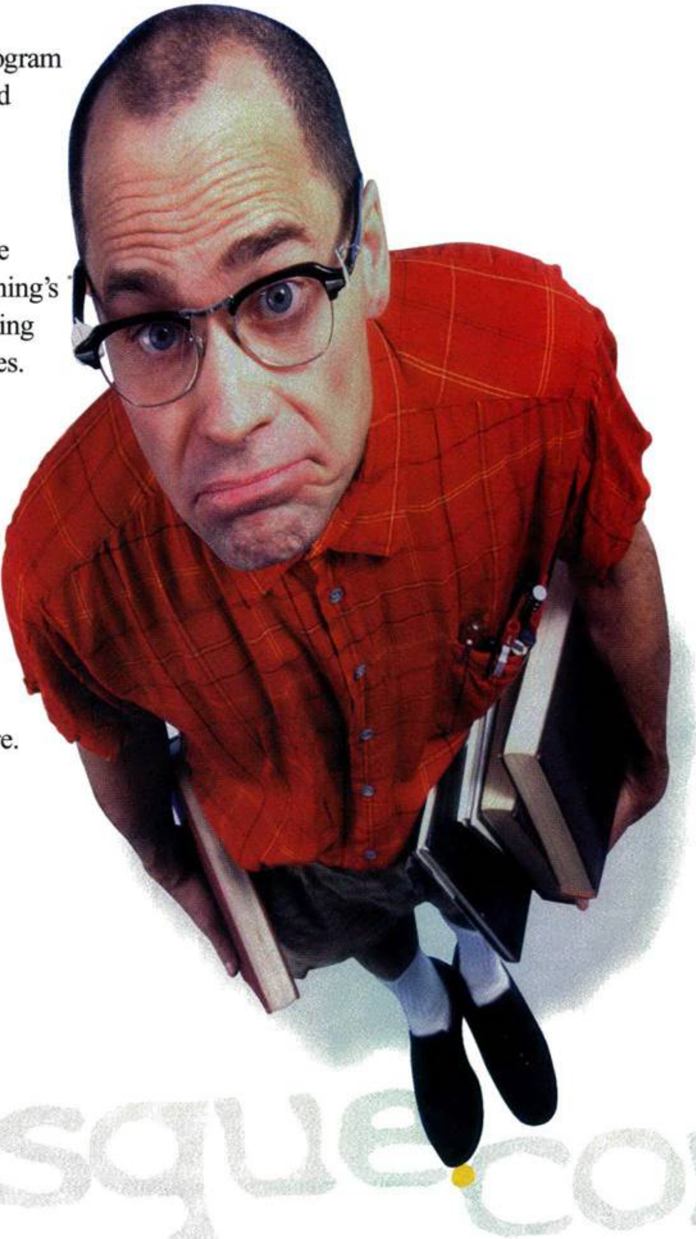

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Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

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Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

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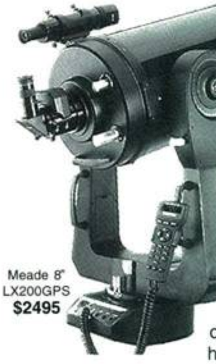
Never before have so many features been packed into one telescope series. And never before have go-to scopes been so easy to use. The new LX200 GPS scopes – the widest variety of go-to scopes on Earth – have just about all the features you've been dreaming about since you started astronomy. Fully automatic GPS alignment, including true north and true level sensors and automatic magnetic declination correction that's unavailable in competitive scopes; mirror lock to eliminate image shift when using the supplied 4-speed electric focuser; a database of over 125,000 stars and objects; flashlight battery operation; and so much more. The Meade GPS scopes are designed to let you spend more time looking *at* celestial objects and less time looking *for* them. And isn't that what you want out of a telescope? With literally hundreds on order, we probably have your Meade GPS scope waiting for you.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Losmandy G-11

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$599 for a 4" . . .

$599
NexStar 4

The 4000-object computer of the new **Celestron NexStar 4** go-to Maksutov-Cassegrain is standard equipment, not an option as it is with some scopes. The computer's hand control can be used even when docked conveniently in the scope's sleek single fork arm mount. A long eye relief Star Pointer red dot finder makes aligning on the skies a snap. The AA battery-operated tabletop NexStar 4 is so easy to use that you'll be observing only minutes after you take it out of the box. At a mere $599, *complete,* it's almost $200 less than competitive 4" go-to Maksutovs.

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8" f/6 Discovery DHQ	$399, plus $49 freight
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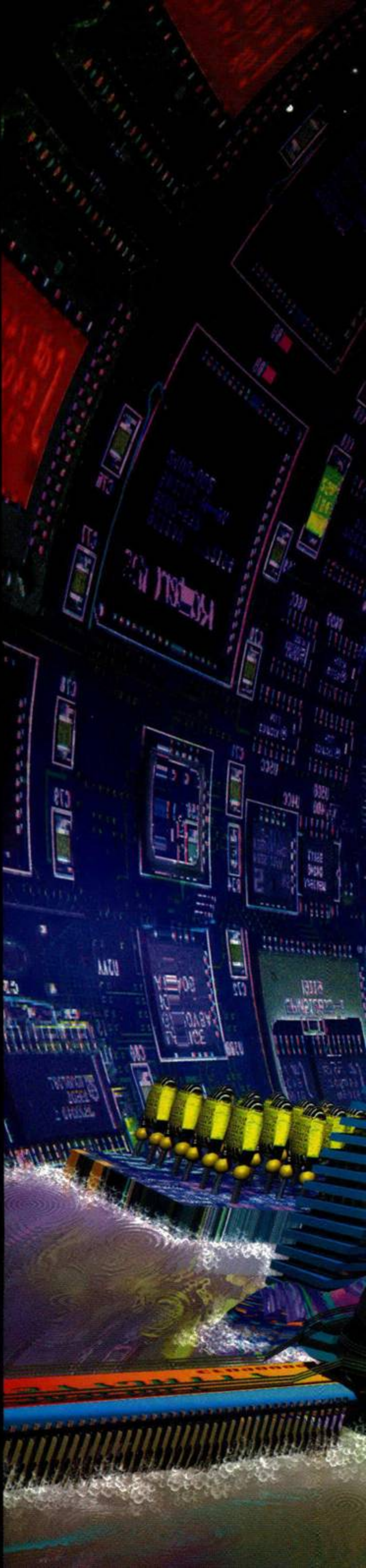
Who Will Inherit The Universe?

The ultimate survival of advanced civilizations might derive from an ability to harness the forces of nature.

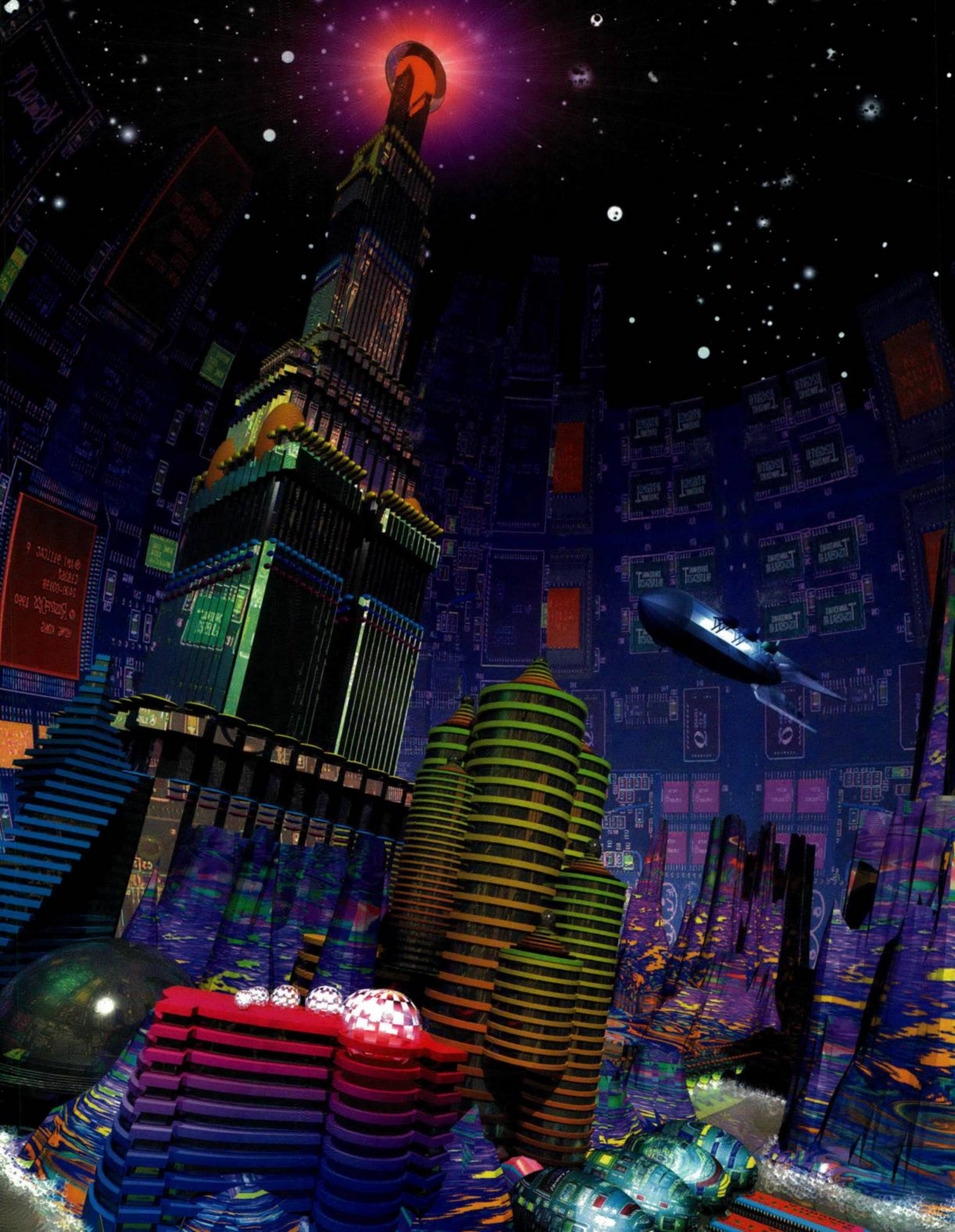
by **Michio Kaku**

Gazing up at the myriad stars visible to the unaided eye on a dark night, it's easy to wonder if any might sustain civilizations possessing capabilities eons beyond our own. But what would such advanced civilizations be like, and what sorts of feats could they be capable of performing? Can humans really hope to join their hypothetical ranks and one day control the weather, harness the power of the sun, or colonize the Milky Way Galaxy?

At first, it may seem foolish to describe an advanced civilization millions of years ahead of our own. After all, only a century ago, who could have predicted the widespread use of jet aircraft for travel, multiple roundtrip journeys to the moon, or the development of the Internet? How could we ever hope to characterize civilizations one hundred years beyond ours, not to mention one thousand or one million years?



Paul Wiley



Given that our civilization is barely a few thousand years old, we can't help but let our imaginations run wild, conjuring up fantastic possibilities.

Still, humanity's quest to determine the features of advanced civilizations is not hopeless. No matter how many millions of years may separate them from us, one truth remains constant: Their actions must obey the fundamental laws of physics. In fact, scientists have, over the last few decades, employed knowledge of physical laws to analyze hypothetical advanced civilizations in great detail, beginning with the seminal work of Russian astrophysicist Nikolai Kardashev.

In 1964 Kardashev published a paper in the *Journal of Soviet Astronomy* in which he categorized extraterrestrial civilizations into Types I, II, and III, ranked according to their capacity to harness a ubiquitous and measurable quantity — energy. In truth, the logic behind his classification is startlingly simple. Because energy, by definition, is the "ability to do work," civilizations could be quickly organized according to their output, for example, in simple universal units such as horsepower.

Kardashev's analysis is particularly useful given that the successive stages of human history can likewise be easily ranked according to energy assets, from prehistoric times (when we only possessed the power of our hands, about one-fifth of a horsepower), to slavery (when kings had hundreds of horsepower at their disposal), to feudalism (thousands of horsepower), to the industrial revolution (millions of horsepower), and finally to modern times (billions of horsepower).

But the real importance of Kardashev's work comes with the realization that, for the first time, a scientist had replaced wild unconstrained speculations with quantitative discussions of physical laws. And for nearly four decades now, scientists have been working to determine the rate of evolution of such civilizations, to detail their mastery of various energy sources, and to place upper and lower bounds on their possible technological sophistication. In the meantime, they've generated a road map to immortality — hazards, obstacles, and pit stops included.

Because Kardashev's classification was based on universal, stable sources of energy, such as planets, stars, and galaxies, we know the energy output of each type of civilization. In turn, this makes it possible to compute the upper limit of energy available to each.

By definition, Kardashev's Type I civilization is a planetary one, possessing the ability to harness the energy reserve of an entire planet — up to one trillion (10^{12}) horsepower. A Type II civilization is a stellar one, capable of controlling the energy output of a single star — up to 100 billion trillion (10^{23}) horsepower. Finally, a Type III civilization is one that has outstripped the energy output of a single planet or star, and has begun to construct a galactic civilization spanning many star systems. Type III civilizations possess an energy capacity of roughly 10 billion trillion trillion (10^{34}) horsepower.

Humankind's energy capacity at the dawn of the 21st century currently qualifies us for Type 0 status. (At present, our entire planetary energy production is a relatively puny 10 billion (10^{10}) horsepower.) We derive our energy not from harnessing global forces, but by burning tiny pockets of the fossil remains of dead plants (oil and coal). Moreover, we can barely forecast trends in the weather, let alone control them.

But since economic activity and energy consumption are roughly proportional to each other, and since we can safely assume that our planet's energy consumption grows at the modest rate of a few percent per year, it shouldn't take long for ours to evolve into a Type I civilization. Physicist Freeman Dyson of the Institute for Advanced Study in Princeton, New Jersey, estimates that, within 200 years or so, we should attain Type I status.

Indeed, we can already see the seeds of a Type I civilization developing all around us. Like it or not, we are seeing the inexorable movement toward a planetary language (English), a planetary communication system (the Internet), a planetary economy (the forging of the European Union, NAFTA, etc.), and even the beginnings of a planetary culture (via mass media, TV, rock music, and Hollywood films). Because Earth is finite but the rate of energy and telecommunications expansion is exponential, it is inevitable that, barring a catastrophe, we will rise to Type I status. Moreover, looming natural catastrophes might generate the necessary impetus to move more quickly to this end.

In retrospect, we know that Kardashev's analysis only placed upper limits on the growth of advanced civilizations, dictated by the maximum energy output of planets, stars, and galaxies. Given the recent interest in meteorite impacts, climatic changes, supernovae, and other natural catastrophes, astrophysicists have now tried to place lower limits on them as well. Indeed, any advanced civilization must grow fast enough to avoid life-threatening disasters. It's a cosmic race against time — fall below the threshold and they will perish.

For example, on Earth, ice ages take place on a timescale of tens of thousands of years. Because Type I and Type II civilizations are likely to encounter various atmospheric or climatic disasters, they must learn to modify the weather within that time frame. A new ice age may commence within a span of thousands of years, which will bury our Type 0 civilization under mile-high ice sheets. If a civilization cannot progress to the next energy level, it must face extinction.

There is also the danger of huge meteorite and comet impacts large enough to destroy most species of life on the planet. Therefore, our Type 0 civilization must evolve into a Type I civilization in order to prevent meteorite and comet impacts, or die. But since we expect civilization-killing meteorites and comets on a time scale of hundreds of thousands to millions of years, this should not pose too much of a problem for our Type 0 civilization.

For us, the real danger is not external, natural threats, but internal catastrophes, such as terrorism, nuclear warfare, and global pollution. Indeed, it is inevitable that any Type 0 civilization emerging in space will discover nuclear weapons and generate large quantities of chemical waste. Thus, the main obstacle preventing the transition from Type 0 to Type I status is strictly self-inflicted. And perhaps the most dangerous transition of all is the one from Type 0 to Type I status.

Eventually, after several thousand years, a Type I civilization will exhaust the power of a planet, and will be forced to derive its energy by consuming the next available source of energy — their star. At a modest growth rate of 1 percent per year, a Type I civilization should be able to make the transition to Type II within about 3,000 years, according to Kardashev.

Dyson has proposed that a Type II civilization may build a gigantic sphere around its star to more efficiently capture its total energy output. The sphere, speculates Dyson, may not necessarily be solid, but perhaps a large collection of energy-gathering, orbiting colonies, resembling the Oort Cloud of comets.

But even concealed by a Dyson Sphere, a Type II civilization should be readilly detectable from space. By the Second Law of Thermodynamics, these protective spheres will gradually heat up and emit large quantities of infrared radiation. Dyson, in fact, has long advocated looking specifically for infrared emission from distant spheres, to identify such advanced civilizations.

The most worrisome natural threats to Type II civilizations come from nearby supernova explosions and gamma-ray bursters, whose sudden eruption could irradiate their planet with a withering blast of x rays or gamma rays, killing all life. Fortunately, such titanic explosions are rare. (Supernovae occur in our galaxy at the rate of about one or two per century.)

Perhaps the most interesting of all civilizations is the Type III civilization, which has exhausted the power of a single star and has reached for other star systems. A Type III civilization, harnessing the power of a galaxy, has a maximum energy output of about 10^{34} horsepower. Growing at a rate of 1 percent per year, Kardashev estimated that it would take 6,000 years or more for us to attain Type III status.

Type III civilizations are most promising, because they possess the greatest capacity for achieving immortality. Ice ages can be altered, meteorites can be deflected, and even supernovae or gamma-ray bursters will damage a small part of a Type III civilization. Once a Type III civilization evolves in a galaxy, it should last for millions or even billions of years.

As we currently live about 15 billion years after the Big Bang, scores of Type I and II civilizations may have risen and perished long before humans arrived on the scene. But if a Type III developed in our galaxy since the Big Bang, it could still be here. This led Carl Sagan and others to speculate that a Type III civilization may exist within the Milky Way Galaxy. In fact, it's the premise that intelligence searches like SETI are based on.

In recent years, Kardashev's analysis has also been modified by the progress in artificial intelligence, nanotechnology, and biotechnology.

By far the most mathematically efficient method to explore the galaxy is via artificial intelligence: To send fleets of robotic Von Neumann probes throughout the galaxy (named after mathematician John Von Neumann, who established the mathematical laws of self-replicating systems).

A Von Neumann probe is a small robot designed to reach distant star systems and create factories. Such a probe would reproduce copies of itself by the thousands. Interestingly enough, a dead moon rather than a planet would make the ideal destination for Von Neumann probes, since they could easily land and take off from these moons due to their low gravity, and also because the moons would not be eroded.

Von Neumann probes could live off the land, mining the raw ingredients to build a robot factory.

They would create thousands of copies of themselves, which would then scatter and search for other star systems.

Like a virus, just one self-replicating Von Neumann probe would exponentially generate a sphere of trillions of such probes, expanding in all directions, increasing in size at a fraction of the speed of light. In this fashion, even a galaxy 100,000 light-years across, such as the Milky Way Galaxy, might be completely analyzed within a million years.

Physicist Paul Davies of the University of Adelaide in Australia has even raised the possibility of a Von Neumann probe resting on our own moon, left over from a previous visitation in our system eons ago. (If this idea sounds a bit familiar, that's because it was the basis of the film *2001: A Space Odyssey*.)

Davies speculates that a spacefaring civilization could use nanotechnology to build miniature probes, perhaps no bigger than your palm, to explore the galaxy. "The tiny probes I'm talking about will be so inconspicuous that it's no surprise that we haven't come across one. It's not the sort of thing that you're going to trip over in your backyard. So if that is the way technology develops, namely, smaller, faster, cheaper, and if other civilizations have gone this route, then we could be surrounded by surveillance devices."

This analysis has also been modified by advances in biotechnology, opening up entirely new possibilities. These probes may act as lifeforms, reproducing their genetic information in space, mutating and evolving at each stage of reproduction to enhance their capabilities in Darwinian evolution, and may have their own forms of artificial intelligence to accelerate the search for intelligent life.

Years ago, contemplating the death of the sun, the philosopher Bertrand Russell wrote what is arguably the most depressing phrase in the English language: ". . . All the labors of the ages, all the devotion, all the inspiration, all the noonday brightness of human genius, are destined to extinction in the vast death of the solar system, and the whole temple of Man's achievement must inevitably be buried beneath the debris of a universe in ruins . . ."

Today, we realize that sufficiently powerful rockets may spare us from the inevitable death of our planet or even the sun.

But how do we escape the death of the universe itself? It seems inevitable that all intelligent life in the universe will die when the universe perishes — either in a hot collapse or frigid runaway expansion.

Astronomer John Barrow of Cambridge University writes, "Suppose that we extend the classification upward. Members of these hypothetical civilizations of Type IV, V, VI . . . and so on, would be able to manipulate the structures in the universe on larger and larger scales, encompassing groups of galaxies, clusters, and superclusters of galaxies." Civilizations beyond Type III may have enough energy to escape our dying universe via holes in space.

With recent advances in quantum gravity and superstring theory, there is renewed interest among physicists about energies so vast that quantum effects can rip apart the fabric of space and time to create wormholes. (Like Alice's Looking Glass, a wormhole is a hole in space, allowing one to instantly travel across vast distances in space and time.)

Although it is by no means certain that quantum physics allows for large, stable wormholes, this does raise the remote possibility that a sufficiently advanced civilization may be able to migrate via holes in space. If one can successfully navigate through stable wormholes, then faster-than-light travel is no longer a problem. They merely take a short-cut through the galaxy. In effect, this would greatly cut down the transition between a Type II and Type III civilization.

The evolutionary process forces lifeforms to leave their environment when it becomes lethal. Obeying this evolutionary imperative, perhaps an advanced civilization, facing the death of its universe, will create another.

Physicist Alan Guth of MIT, one of the originators of the inflationary universe theory, has computed the energy necessary to create a baby universe in the basement. The required temperature is 1,000 trillion (10^{15}) degrees, which would be within range of civilizations beyond Type III. (He also confided to me that it may be dangerous for us to cook up a universe in our basement: the energy release from even a tiny universe would be equivalent to several hydrogen bombs.)

In the next few years, scientists will use satellite arrays to identify hundreds of Earth-like planets in space. And perhaps one day, amateur astronomers will experience something of an existential shock as they gaze toward the night sky, holding in their hands an encyclopedia listing the coordinates of hundreds of small, Earth-like planets, wondering if any of them harbor life, perhaps some with civilizations more advanced than our own. ■

Michio Kaku is professor of theoretical physics at the City University of New York, and author of international bestsellers Hyperspace *and* Visions *(Anchor Books/Doubleday). You can find him on the web at www.mkaku.org.*

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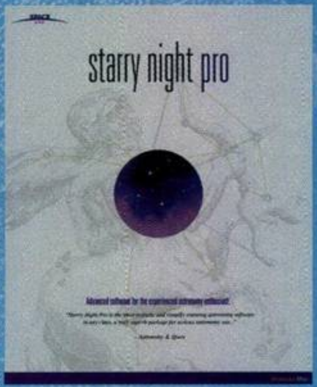

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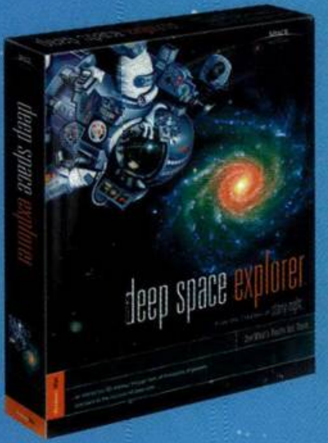

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Outer Space Laws

Who's gonna make 'em?

When it comes to pickpockets aboard the space station or spacecraft collisions, the high heavens may require some new laws.

by David Tenenbaum

When an artist recently proposed — we're not making this up — to rouge the dark side of the moon with millions of red lasers beamed from Earth, newspaper editorials buzzed about whether someone has the right to cross-dress our lunar companion.

When rich man-tourist Dennis Tito muscled his way aboard the International Space Station last year, NASA responded with a "no hitchhiking" policy, and struggled to embody a set of criteria outlining who can — and can't — ride in the $60-billion mobile home-in-orbit.

If humans finally colonize space, who will govern these extraterrestrial colonies? On whose laws will their legal system rest? Will these space pioneers enjoy the same civil and human rights that Westerners take for granted, or will the uniquely dangerous environment of space restrict their freedom?

Gary Baseman

Most people don't give space law a second thought. But it turns out that far more than just lunar face-painting, space tourism, and human rights will need regulation in the great upstairs. Already, companies that launch satellites worth upward of $100 million want insurance against crash-and-burn on launch, and collision coverage against impacts with space junk once they're in orbit. They will also need liability coverage against the off chance that a plummeting rocket tail fin will whack the rear fin of Uncle Phil's prized Dodge DeSoto. So far, so simple. But who pays — and how much — if a satellite fails to reach its target orbit, but remains usable for some other purpose? And who is responsible for a satellite launched by Russia on behalf of a multinational corporation that just happens to carry components made in the good ol' U.S.A.? Who resolves disputes over commercial use of space, such as rights to mine rare minerals on an asteroid?

To untangle this legislative mess, we now have institutes of space law, professors of space law, even law journals devoted to extraterrestrial affairs.

Over the past third of a century, mushrooming military, scientific and commercial use of space has sparked an explosion in the need for some type of governance over the high heavens. Upon a foundation of five treaties, written in mostly vague, sweeping language, rests a welter of scarcely tested and often incompatible national laws. To untangle this legislative mess, we now have institutes of space law, professors of space law, even law journals devoted to extraterrestrial affairs.

It's safe to say that when Yuri Gagarin launched into Earth orbit in 1961, his Vostok I spacecraft carried nary a law book. But space is no longer a frontier where the law belongs to the guy with the fastest draw (although, to be fair, the United States and the Soviet Union had a bit more clout, space law-wise, than Burma or Fiji). So instead of training test pilots and scientists, maybe NASA should save a few seats in its zero-gravity trainers for attorney-astronauts. In the era of Yuri Gagarin and Alan Shepard, space was the place to "just do it." These days, you may be able to do it after running it past legal.

Digging Up Roots

Space law is rooted in the cold war and space-race of the 1960s, explains George Robinson, a New York lawyer with 30 years' interest in the subject. "The Soviets and Warsaw Pact didn't know what NATO and the U.S. could do, and vice versa," so both sides "negotiated a very general treaty in 1967 to make sure neither no one went up to the moon, planted a flag, and said 'it belongs to us."

By February 2000, the United Nations-sponsored Outer Space Treaty had been ratified by 96 nations and signed by 27 others. Article I set forth a utopian vision: "The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific involvement, and shall be the province of all mankind."

We trust that wording would have annoyed past explorers like Christopher Columbus, who claimed the New World for the Spanish crown. But the treaty went further by:

- According "free access to all areas of all celestial bodies."
- Guaranteeing freedom of scientific research.
- Banning nuclear weapons or weapons of mass destruction.
- Requiring signatories to regard astronauts as "envoys of mankind in outer space."

Four subsequent treaties fleshed out those goals by requiring states to rescue and return astronauts and spaceships, and be held accountable for damage caused by their spacecraft.

Most of today's space law stems from rules of the air and sea, devised to regulate activity in hostile environments and may require the "cessation of certain rights, based on the fact of the need to stay alive." That's the analysis of Kathleen Woody, chief justice of the Space Supreme Court — a body with no real jurisdiction formed by members of the United Societies in Space (USIS), a private organization devoted to the future of space living and travel. The clearest outgrowth of this heritage, she says, is the absolute rule of the captain, at sea, in the air, and in space. "You voluntarily go under the authority of the captain, because it's a hostile environment" (Indeed, in the wake of the September 11, 2001 terrorist attacks, airplane captains stress that they are in command "without question and limitation").

Some aspects of space liability law even predate aviation law, says Jonathan Epstein, co-chair of the American Bar Association's commercial space division. Before biplanes ruled the skies, those who engaged in "ultra-hazardous" activities like dynamite blasting for mining and construction were liable if they harmed any outsiders. Epstein says this principle logically transferred to aviation, making "owners of aircraft absolutely liable for any damage caused on the ground."

From there, it was a short jump to the 1972 Space Liability Treaty, which said, essentially, that if your antique, sky-blue convertible is crushed by a falling satellite, then you're not negligent if you failed to park in a bunker. In fact, this treaty says you can collect from the satellite's owner.

Liability laws are, unfortunately, feckless against a key hazard of spaceflight — space junk. How do you identify the owner of a paint chip that blasted your spacecraft's front "windshield" at 20,000 miles per hour? While NASA is not seeking new laws on orbital debris, it is interested in an international agreement on reducing the hazard, says Lynn Cline, deputy associate administrator for external relations at the space agency.

Treat Thy Neighbor As ...

With people living in space for ever-longer periods, the need to regulate them — not just their equipment — becomes more apparent. In December 2000, NASA published a code of conduct for the International Space Station (ISS) crew. *Astronomy* searched the code for "Thou shalt not kill, maim or dismember thy crewmate" or other injunctions suited to a new frontier, but confronted a decidedly touchy-feely text. The general standard of conduct "shall be such as to maintain a harmonious and cohesive relationship among the ISS crewmembers and an appropriate level of mutual confidence and respect through an interactive, participative, and relationship-oriented approach which duly takes into account the international and multicultural nature of the crew and mission." After such concerns, could the PR front be far behind?

No, in fact, ISS crewmembers must not "act in a manner which results in or creates the appearance of: (1) Giving undue preferential treatment to any person or entity ... and/or (2) adversely affecting the confidence of the public in the integrity of, or reflecting unfavorably in a public forum on, any ISS partner, partner state or Cooperating Agency."

Now they're finally talking Commandments: Thou shalt not take NASA's name in vain.

And by no means is space a lawless frontier where you can, literally, get away with murder — at least not on the space station. The ISS's so-called Intergovernmental Agreement gives criminal jurisdiction to an alleged perpetrator's country. This agreement seems less confusing than an earlier suggestion that each ISS module be governed by the laws of the nation that owned it. Such an approach would ensure a perpetual paycheck for lawyers. What, for example, would happen if an astronaut in the Russian-built docking module shot and injured someone a few meters away in a module built by the United States? In which "country" did this crime occur?

Law of the Landless

Those familiar with salvage operations at sea know that such activity is governed by a toddler's principle (finders keepers). But the 1968 Space Rescue treaty mandates that spacecraft and astronauts be returned to the launching nation. Similarly, just last August, the United States withheld an export license needed by the Chinese to launch a European-built satellite with American components.

No matter how much treaties blather about the peaceful use of space, the number of actual limitations on the military is, well, limited. Spying from space — collecting photos and data on military targets; geologic treasures, such as minerals and fossil fuels; and weather — is permitted. So are weapons that attack satellites — the eyes and ears of modern militaries, which are logical first targets in modern war. Thus as soon as anyone is able to destroy satellites, another nation might interpret the silence of one of its satellites as an attack. A similar hazard attends missile-defense systems, which presumably would knock out satellites easier than more offensive missiles. Although the anti-ballistic missile treaty restricts anti-missile weapons by the United States and Russia, the Bush Administration plans to renounce the treaty. At any rate, under existing law, other countries can apparently develop anti-satellite weapons.

In the long term, space law must regulate far more than pickpocketing on the space station and attacks on satellites. For example, with more and more nations launching spacecraft, there might well be a need for space "traffic laws." Yet such rules of the cosmic road would pose a challenge — as one travels farther out in deep space the notions of up and down or left and right are hard to interpret. According to the International Institute of Air and Space Law at Leiden University in the Netherlands, the best rule, at least for now, is to keep others informed of where your spacecraft happens to be: "The basic traffic rule is the intergalactic equivalent of honking your horn!"

"If there's a colony on Mars or the moon and it becomes self-sufficient, is that part of the country that created it? Are the residents still Americans — are they something else? At what point do they become their own entity?" asks Kozlowski.

Declan O'Donnell, a Denver tax lawyer, has tried to answer such questions with an audacious effort called United Societies in Space (USIS), which, in 2000, ratified a space constitution. The engineers, lawyers and futurists in USIS chose 300 delegates, he says, who have accepted the burden of preparing a legal basis for exploring and exploiting deep space.

Although it may be news to you, O'Donnell says, "Astral law, or common law in outer space, is starting to mature." O'Donnell says the group is following precedent set in England during the crusades, when the king

and nobles were busy fighting for the Holy Land. Knights and nobles typically asked neighbors to handle their affairs, and to pass the land to the oldest son if they ended up impaled on a scimitar. Originally, these agreements lacked force of law, but over time, trust contracts were written to guarantee that heirs got their estates. When the king failed to object, O'Donnell says, the new arrangements became accepted "common" law, and, ultimately, the basis for the British and American legal systems.

O'Donnell argues that the precedent applies to outer space, because the United Nations Committee on the Peaceful Uses of Outer Space has failed to meet the emerging needs of spacefarers, much as the kings of England failed to meet the needs of crusaders 700 years ago.

To Get Law, Make Law

At any rate, if you didn't know about the space constitution, you wouldn't know that space also has a regent — a temporary space knight — and his name is, yes, Declan O'Donnell. Again, it's just legal precedent, says O'Donnell. Now, as during the crusades, somebody must take the reins and prevent the fires of anarchy.

Woody, who heads the USIS Space Supreme Court, sees the space constitution as merely a legislative model that will surely be modified with experience. Space law, she adds, must be built on the best earthly law, including English common law, consumer protection, and the United Nations Charter. The space constitution, she says, adopts the U.N. Universal Declaration of Human Rights and extends it to ban slavery of "sentient beings." That, she says, should prevent enslaving spacelings who differ physically (and/or quite possibly mentally) from people born in the gravity.

Such wording might respond to what the International Institute of Air and Space Law called an "amazingly difficult question to answer" — human rights for extraterrestrials who "have an intelligence fundamentally different than ours." Would we — should we — force them to obey our laws? What if they want to rule the roost?

Although such an encounter is unlikely, experts at Leiden said, "We better have some lawyers in the welcoming committee to help solve such very fundamental philosophical issues with legal reasoning and arguments."

That's placing boundless faith in lawyers, but even before we encounter extraterrestrials, we still face basic and weighty decisions. Will the exploration of space, as the Outer Space Treaty dictates, "be carried out for the benefit and in the interests of all countries"? Perhaps. Will space and the celestial bodies "be free for exploration and use by all States without discrimination of any kind"? Again, it's a possibility. But once you dive into the fine print beneath this lofty language, you enter a zone of zero-legal-gravity where words just don't seem to mean what you expect.

For example, some space entrepreneurs worry investors will shy from businesses if space must be explored for the benefit of all. But Paul Larsen, who teaches space law at Georgetown University, sees wiggle room. If, he says, orbiting solar-power satellites were built, for ease of launching, on the moon, then the profits could be private while the moon remained public. "You don't need to own the moon. You just need to get the resources." The sea, he points out, is not owned by any nation, but "you can fish in the ocean and sell the fish."

A similar analysis might apply to mining the moon for Helium 3. This isotope, rare on Earth, has been deposited on the moon in large quantities by the solar wind. Helium 3 could be ideal for fueling fusion power generators, according to Gerald Kulcinski, a University of Wisconsin nuclear engineer who has long advocated the idea and says one ton of this isotope contains the energy equivalent of $4 billion worth of crude oil.

If the "common benefit of mankind" does not preclude private profits, likewise, the seemingly clear-cut duty to return astronauts is "completely up for interpretation," says Henry Hertzfeld, senior research scientist at the Space Policy Institute at George Washington University. "Yes, there's a treaty on rescuing astronauts, but does an astronaut have to be a government employee?" If pilots who work for private companies are not considered "astronauts," they may not be covered by the same generous benefits, he suggests.

Treaties, says Hertzfeld, "were written to solve problems and questions that were current when they were written." Whether they are flexible enough to adapt from brief orbital flights to exploration of deep space "depends on the interpretations."

"Maybe what we need is some case law...You begin to develop some precedent, and decisions." Not every decision would be logical, Hertzfeld admits, "but over time you will develop a good feel" for the unique demands for regulating human conduct in the endless frontier of space.

To get law, make law. Spoken like a true lawyer. Comrades: Steer hard right, full thrust, and pass the statute book.

David Tenenbaum is a staff writer at The Why Files *(http://whyfiles.org) and a veteran freelance science writer. He's considering going back to school to become a spaced-out lawyer.*

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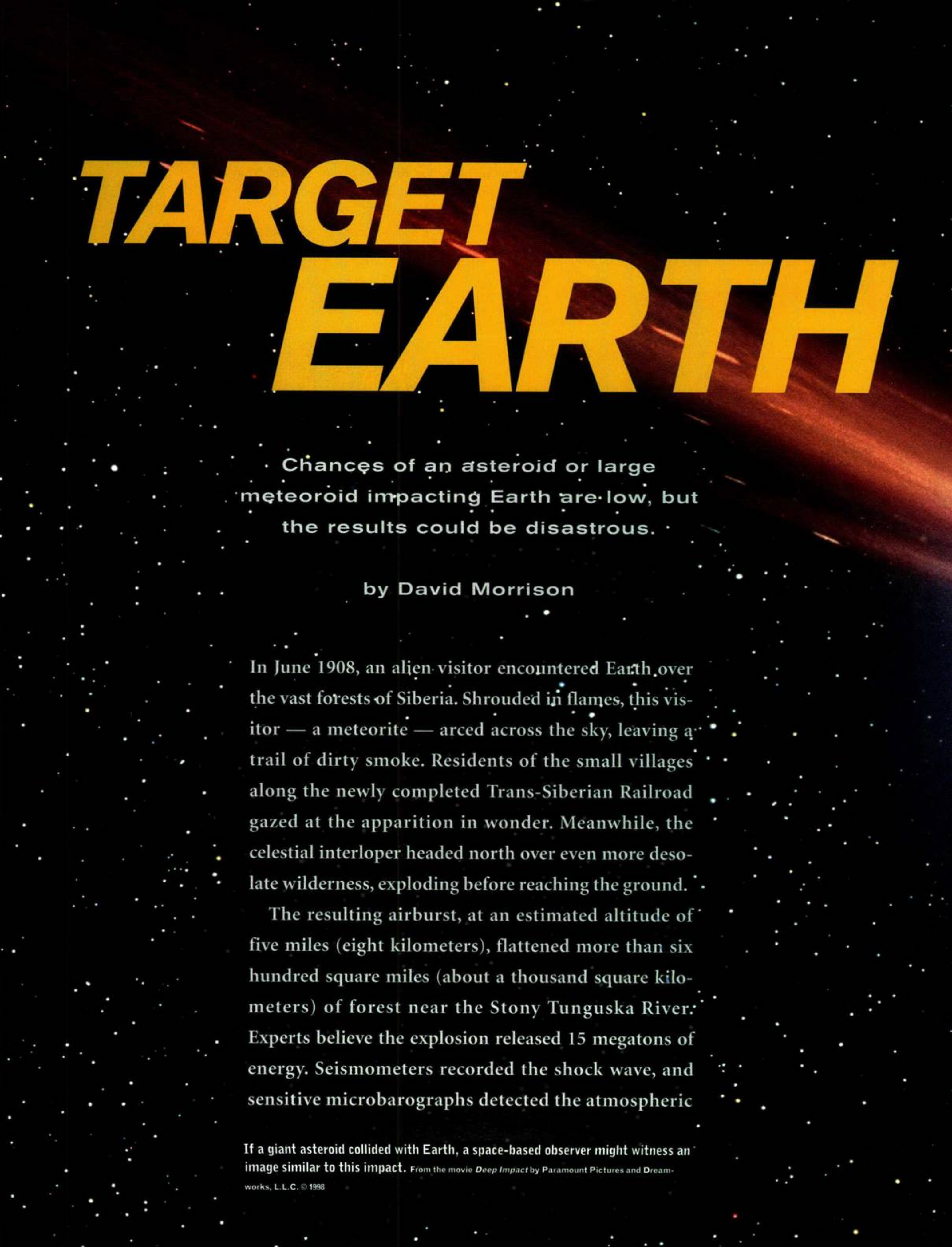
TARGET EARTH

Chances of an asteroid or large meteoroid impacting Earth are low, but the results could be disastrous.

by David Morrison

In June 1908, an alien visitor encountered Earth over the vast forests of Siberia. Shrouded in flames, this visitor — a meteorite — arced across the sky, leaving a trail of dirty smoke. Residents of the small villages along the newly completed Trans-Siberian Railroad gazed at the apparition in wonder. Meanwhile, the celestial interloper headed north over even more desolate wilderness, exploding before reaching the ground.

The resulting airburst, at an estimated altitude of five miles (eight kilometers), flattened more than six hundred square miles (about a thousand square kilometers) of forest near the Stony Tunguska River. Experts believe the explosion released 15 megatons of energy. Seismometers recorded the shock wave, and sensitive microbarographs detected the atmospheric



If a giant asteroid collided with Earth, a space-based observer might witness an image similar to this impact. From the movie *Deep Impact* by Paramount Pictures and Dreamworks, L.L.C. © 1998

pressure wave around the globe. The following night in England a strange glow suffused the northern sky, so bright that people could read newspapers at midnight.

The Tunguska event is now recognized as a collision of Earth with a stony asteroid, nearly 200 feet (60 meters) in diameter. Scientists use data from Tunguska to calibrate an understanding of terrestrial impact hazards. Together with the much larger dinosaur-killing impact of 65 million years ago, the Siberian event serves as a benchmark of the hazards associated with cosmic collisions.

Had the Tunguska projectile struck near a city, it would rank among the world's most well-known natural disasters. However, because water covers three-fourths of the world's surface and much of the land area is sparsely inhabited like Siberia, few asteroid impacts would result in the destruction of a city with millions of casualties. If the Tunguska event had taken place in an ocean, or if the new seismic and pressure instruments had not been running, no record would exist.

The Tunguska impact remained a unique event in the century that followed. Therefore, it's easy to imagine that if Tunguska had exploded over an ocean, even today scientists might not recognize the impact hazard posed by asteroids. That leaves the dilemma of treating the Tunguska impact as a fluke, or anticipating another catastrophic asteroid impact. Some answers may lie in the moon's cratering record.

If the Tunguska asteroid had hit the airless moon instead, it would have exploded at the surface and excavated a crater a little over a half-mile (one kilometer) across. The moon shows evidence of thousands of similar impact craters of varying sizes. Roughly 17 percent of the lunar surface was resurfaced by volcanic flows about 3.5 billion years ago — after the period of heavy bombardment ended. Because scientists know the age of the dark lava flows of the lunar maria, they can count those craters and estimate average impact rates.

Planetary geologist Gene Shoemaker, considered the father of impact studies, first made this calculation nearly two decades ago. He estimated that a Tunguska-size (15 megaton) impact should occur somewhere on Earth about once per century, on average. For such a rare event, it's not surprising that, at most, only a few ambiguous historical (and mythical) possibilities — but no authenticated records — exist.

By taking Shoemaker's conclusion about lunar craters and using much smaller and more frequent impact events, scientists can extrapolate an independent estimate of Earth's current impact rate. As my colleague Clark Chapman (of the Southwest Research Institute in Boulder, Colorado) and I realized a decade ago, the same arguments that predict a Tunguska-type impact once per century lead us to expect an impact with the energy of the Hiroshima atomic bomb (15 kilotons) about once or twice per year. At first encounter, this seems like an obvious contradiction: If an explosion the size of an atomic bomb occurred every few months, print and visual media would report them.

To resolve this paradox, look at what happens to incoming projectiles. The smaller the object, the higher in the atmosphere it decelerates and explodes. A projectile with the energy of the Hiroshima bomb explodes so far above the surface that people are unaware of the event unless they happen to be looking. Meteoroids the size of the Tunguska projectile explode in the lower atmosphere. Only the largest projectiles make it to the ground at a high speed, blasting out craters.

This still does not verify whether 15-kiloton explosions are occurring in the upper atmosphere every few months. Fortunately, there is a way to test this prediction. For the past quarter century, the military and intelligence agencies of

GONE WITH THE WIND?

In 1995, Hurricane Luis wreaked havoc in Simpson Bay Lagoon on St. Maarten. C. A. Ryback

Another possible effect of an asteroid impact in Earth's oceans is the so-called "hypercane," hypothesized by MIT researcher Kerry Emanuel. This freakishly large hurricane would send winds hurtling at nearly the speed of sound — about 760 mph (1,216 kph).

Emanuel's computer simulations showed that a large asteroid would gouge an enormous, albeit fleeting, "crater" in the ocean — a crater that would refill with water moving so quickly that it would heat to a literal boil. This water would evaporate almost instantaneously to the upper atmosphere, thus creating a near-vacuum. Emanuel estimates that air pressure over the impact site would drop to 200 millibars. (The lowest hurricane pressure recorded is 890 millibars; normal atmospheric pressure is 1,000 millibars.) With a sudden void to fill, surrounding air would race in, spawning mighty winds. Those winds, coupled with the force of Earth's rotation, would initiate a hypercane.

Computer simulations suggest that the extraordinarily fast rotation of a hypercane would create updrafts at nearly 150 mph (240 kph), which would suck tons of accumulated debris and saltwater vapor 26 miles (42 km) into the stratosphere. This debris would eventually cloud much of the world's stratosphere, resulting in an effective solar shield that could persist for months and snuff out the sun-starved life below.

Emanuel also contends that the ocean water would become so agitated that numerous other hypercanes could evolve for days after the original storm.
— Paul Morledge, associate editor

the United States and Russia have been monitoring Earth from orbit, looking for rocket launches or clandestine nuclear tests. Military surveillence satellites observe the entire planet, which means that the full global area of Earth serves as a meteor detector.

During the Cold War, these data were classified. We now know, however, that the military and intelligence agencies were fully aware that they were detecting large meteor events. They saw the meteors, determined that they posed no national security danger, and promptly discarded most of the observations. Now, every few months the U.S. Air Force issues a press release on detection of large meteors.

On February 1, 1994, half a dozen satellites over the Western Pacific tracked a large meteor's plunge through the atmosphere using visible and infrared cameras. The incoming rock broke into several pieces, with the largest descending to an altitude of 13 miles (21 km) before exploding. The total energy was estimated at 50 to 100 kilotons, several times larger than that released over Hiroshima. Because the entry took place over open ocean, there were few witnesses and no possibility of collecting any meteorite fragments. Later, Micronesian fishermen reported seeing the final explosion, which they described as "brighter than the sun."

Space data confirm that Earth is currently being bombarded at about the same rate as Shoemaker had deduced from lunar cratering. At least one 15-kiloton atmospheric explosion occurs annually. It therefore follows that the estimate for Tunguska-size impacts is also correct, at roughly one per century.

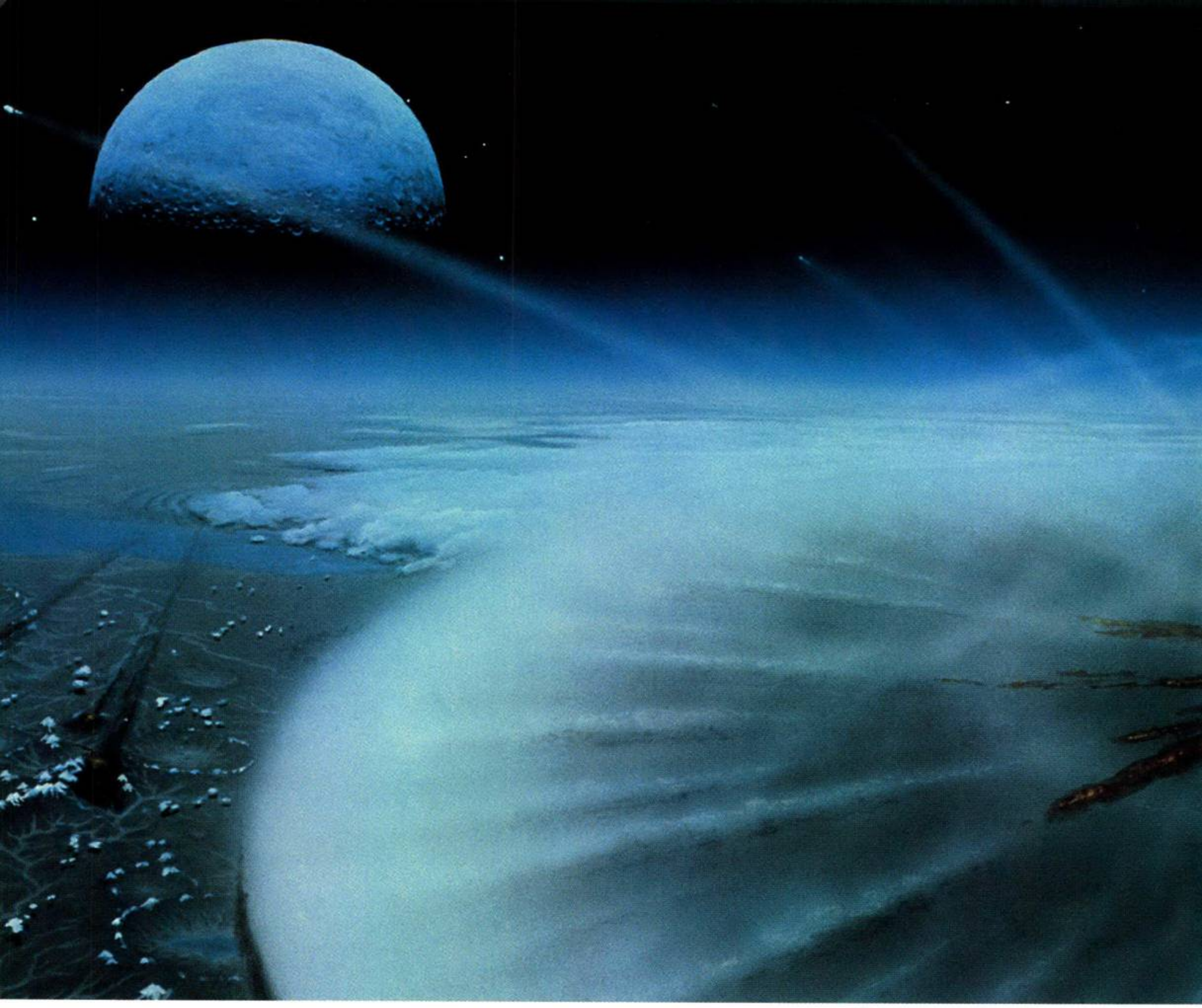
In order to estimate the risk level from impacts of this size and frequency, scientists note that there are no extended global effects from such an explosion; only people and creatures near the impact site are at risk.

Paradoxically, when considering meteoroid impacts, rare events cause more concern than smaller, more frequent impacts. Although the danger of dying as the result of a Tunguska-size impact is very small, the risk increases dramatically with the increasing size of the asteroid: This is because casualties rise at a disproportionately faster rate than the frequency of a larger projectile hitting Earth drops off. While large impacts are exceedingly rare, the fact is that most of the risk is associated with them, and not with the smaller, Tunguska-class impacts.

Of all life-threatening natural or human-caused risks, cosmic impacts represent the extreme combination of very low probability with very high consequences per event.

Likewise, open-ocean impact results prove fodder for another intriguing set of statistical data. Immediate blast effects of an ocean strike are nil, unless an unlucky ship happens to be near the point of impact. The energy of an

The Galileo spacecraft captured this image of asteroid 243 — Ida — as the two passed each other in 1993. NASA/JPL



An asteroid impact would create catastrophic shock waves. Adolf Schaller/AstroMedia Corporation

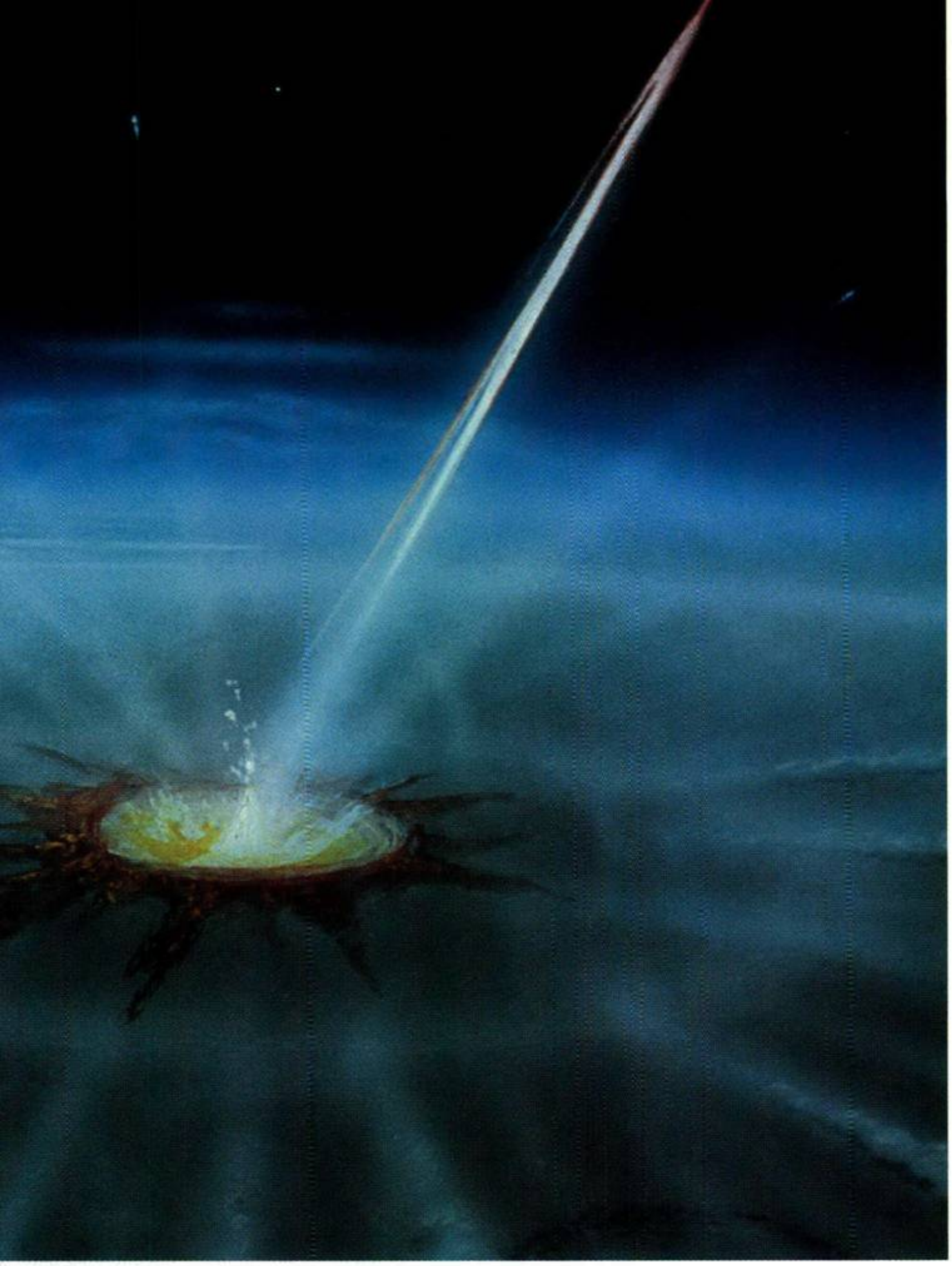
open-ocean explosion dissipates differently than on land. A meteroid impact would produce a large transient cavity that refills instantly as surrounding ocean water rushes to refill it. This sloshing back and forth generates a tidal wave, or tsunami, which propagates outward like the expanding ripples in a pool. As it travels for thousands of miles, the tsunami efficiently transports part of the impact energy across large distances, making the radius of destruction from the expanding tsunami much greater than that from an explosion on land.

An open-ocean tsunami is not dangerous. While the tsunami wave itself is very large, the ocean is very deep, and a nearby ship may not even notice the effects caused at the surface. As the tsunami approaches land, however, the giant wave encounters friction with the shelving sea bottom and grows in height. When the wave breaks and penetrates inland, it towers over the landscape, causing enormous damage and placing coastal populations at risk.

Throughout the world, population centers develop along shorelines or on river estuaries, where there is ready access to fishing and marine commerce. It's a trend that accelerated in the past century, and now more than half of the world's largest cities are on an ocean coast. This population distribution enhances the destructive potential of tsunami.

Little information exists on the formation of a tsunami by an explosion or of the effects when an extremely large tsunami reaches the land. Large tsunami are rare, and those studied originated in undersea earthquakes or landslides — not celestial impacts. Impacts must be larger than the explosion over Tunguska in order to generate a tsumani dangerous enough to affect coastal areas. Such impacts, by asteroids or even comets hundreds of meters in diameter, are exceedingly rare, probably not more than once in tens of thousands of years. The tsunami risk is therefore more difficult to quantify than the risk associated with Tunguska-class impacts on land.

Computational modeling of impacts indicates that there is a threshold size of about one million megatons of energy beyond which the effects of an impact become global. This energy



SPACEGUARD SURVEY

The Spaceguard Survey is an international search for potentially threatening asteroids. It's named after the similar but radar-based search proposed by author Arthur C. Clarke in *Rendezvous with Rama*.

The survey uses a half-dozen specialized optical telescopes. The most successful of these efforts is operated by Grant Stokes and his colleagues at the MIT Lincoln Laboratory. Their twin telescopes, located in New Mexico, scan the sky every clear night except around the full moon, when faint asteroids cannot be detected.

Successive CCD frames of the same area of the sky are computer processed to identify the faint moving images of asteroids against the fixed stellar background.

Once a new asteroid is found, astronomers need to compute its orbit. The additional positions necessary are mostly obtained by a few dedicated amateur astronomers (many of them in Japan and Italy). The amateurs take measurements over successive weeks.

Astronomers then calculate the position of each asteroid forward in time to ensure that it poses no danger of hitting Earth.

NASA's goal is to find 90 percent of the near-Earth asteroids larger than 1 km in diameter by 2008.
—D. M.

corresponds to an asteroid size of between one and two kilometers (just over half a mile to one-and-a-quarter miles) in diameter. Above this threshold, the entire planet is subject to environmental perturbations, primarily from dust blasted into the stratosphere.

As crops fail around the globe, the individual risk goes up as well. Your chance of dying from such a global-scale impact is roughly 100 times greater than from a Tunguska-class impact. In addition, global catastrophes threaten the stability of civilization itself; that is why scientific and public interest focuses on these larger impacts. And that is also why astronomers are actively surveying the sky to find all of the near-Earth asteroids larger than one kilometer in diameter. Today they are more than halfway to achieving this goal, thanks to the Spaceguard Survey.

Funded mostly by NASA, the international Spaceguard Survey discovers about 25 new NEAs (near-Earth asteroids) monthly using specially designed telescopes. Although relatively small (about one meter in aperture), these telescopes are equipped with the most advanced CCD detectors and computers to analyze the data, finding faint moving asteroids against the background of millions of stationary stars.

None of the roughly 1,500 NEAs found so far, including the 530 larger than one kilometer, poses any danger of striking Earth over at least the next century. As the survey progresses, we will eventually eliminate the risk of an unexpected impact from a large asteroid, but the current survey is far from complete at the smaller size NEAs.

Chances are, no comet or asteroid will damage Earth any time soon; however, scientists want to predict the future and prepare in case the unexpected happens. Although we often discuss impact statistics, the situation is actually deterministic. There either is or is not an impact that will take place during our lifetimes.

The challenge for astronomers is not to calculate the statistics, but to go out and discover the next impactor before it hits us unawares. ■

David Morrison is a NASA astrobiologist who has studied the impact hazard for the past decade. Asteroid 2410 Morrison is named in his honor.

The Perfect Storm

Though it stopped short of the 1966 megashower, November's Leonid show delighted observers.

"It was the best shower I've seen in the last 40 years," said veteran meteor observer George Gliba of Greenbelt, Maryland. The November 17/18, 2001 Leonid shower was a classic, with dozens of meteors visible per minute. Full coverage of the amazing event will appear in the March issue.

A blitz of Leonids streaks across an exposure made from near Spruce Knob, West Virginia, at 4,100 feet, where the limiting magnitude was about 6.5. Jerry Lodriguss

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sky Show

february

Catch Mercury and some variable stars.

by Martin Ratcliffe and Alister Ling

Shall I compare thee to a winter's sky? Does the radiant beauty of the night, now rising in the east, have any earthly equal? The northern air may be chilly, but the sparkling crystal dome overhead seems to radiate a personal warmth to all avid skywatchers.

The brightest stars in the sky, save for a few, form the outline of a huge curly number 6 and dominate the eastern half of our view. From the Northern Hemisphere, Sirius twinkles in a frenzied kaleidoscopic display at the bottom of the numeral. In contrast, Capella — a quietly flickering gold — rides high on the number. In the middle, gas giants Jupiter and Saturn shine with remarkable steadiness. By this time next year, the pattern will be broken when Jupiter lies out of the scene to the lower left.

Tree branches pierce the constellation Orion and the star clusters Hyades and Pleiades on a still winter night. Randall Wehler

If you can tear your eyes away from the sparkling grandeur of the eastern sky, you will find tireless Mars glowing like a bright orange star halfway to the zenith in the southwest. Despite its brightness and height, Mars is guaranteed to be a disappointment through the telescope due to its diminutive size of 6". You would have to put your scope at 300x to make Mars the same apparent size as the full moon appears to the unaided eye, and even then you can expect a turbulent view.

Speaking of the moon, it generates some of the most engaging events this month. On the evening of February 16, its crescent form passes a full binocular field below rust-colored Mars. Mark your calendar for Wednesday evening, February 20, when the moon passes in front of the Ringed Planet for the last saturnian occultation until 2014. The best views will come from south of an imaginary line drawn from Hudson Bay to San Francisco. Friday night, February 22, the moon slips in front of Jupiter for Alaskans and northern Europeans, which will mark the last jovian occultation until November 2004. If the full moon looks particularly big on February 27, it should, because it is the closest one of the year. Our lunar companion will look enormous if you catch it right at moonrise or moonset, thanks to the "moon illusion" right above the horizon. Coastal areas accustomed to big tides should expect a particularly large one, depositing lots of shells on the beaches.

Early risers (up by 6 A.M.) are rewarded with a nice apparition of Mercury this month. The swiftest planet in our solar system shows up well only a few times a year, so you need to plan for it. Note where the sun rises, then on mornings following February 10, look about 10° to the right (your fist on an outstretched arm covers about 10° of sky). Mercury hangs about 5° — half a fist-width — above the horizon and looks like a typical star at dawn, but with no other bright stars in the area to confuse the matter. It begins to drop quickly after February 25, so keep looking east in the last week of February for an added treat. Comet LINEAR WM1 rises about 10° to the right of where Mercury was. Make sure you use binoculars, since at a predicted 6th magnitude, this fuzzball will be tough to see from the city.

Now's the time to track down an asteroid using binoculars or a small scope. With binoculars, try leaning against a wall or propping your elbows on the roof of a car to steady the view.

Asteroid 4 Vesta is traveling in Taurus, heading for a close pass with Saturn in March. After you've found Vesta, drop down just a bit to find one of the mysteries of the universe: the rusty star W Orionis, whose brightness varies in an unpredictable way. See this curious phenomenon for yourself.

2002
February

4 Last quarter moon is at 8:33 A.M. EST

8 Saturn is stationary, 5 A.M. EST

9 The moon passes 5° south of Mercury, midnight EST

10 Asteroid Juno is at opposition, 8 P.M. EST

12 New moon is at 2:41 A.M. EST

13 Uranus is in conjunction with the sun, noon EST

14 The moon is at apogee (252,502 miles from Earth), 5:21 P.M. EST

16 Asteroid Ceres is in conjunction with the sun, 8 A.M. EST
The moon passes 5° south of Mars, 7 P.M. EST

20 First quarter moon is at 7:02 A.M. EST
The moon passes 0.6° north of Vesta, 8 A.M. EST
The moon passes 0.2° north of Saturn, 7 P.M. EST (page 62)

21 Mercury is at greatest western elongation (27°), 11 A.M. EST (page 62)

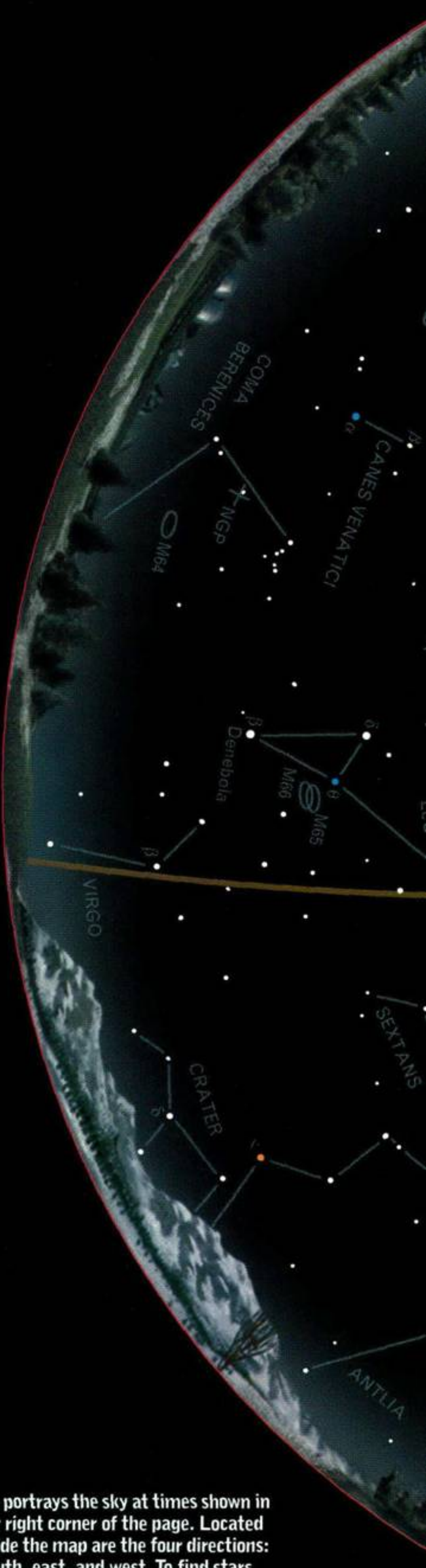
22 The moon passes 0.9° north of Jupiter, 9 P.M. EST

23 Asteroid Flora is at opposition, 8 P.M. EST

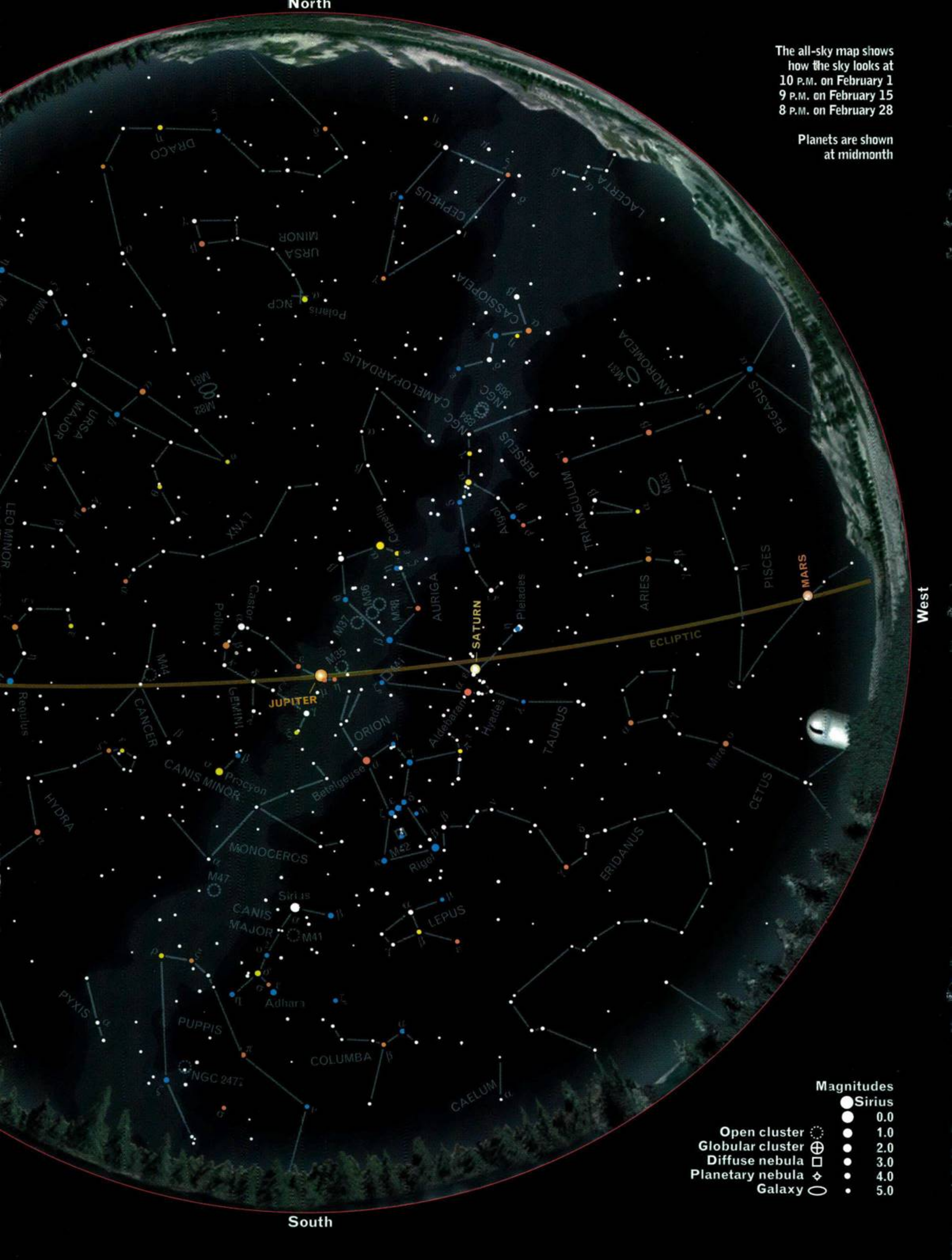
24 Mercury passes 0.5° south of Neptune, 8 A.M. EST

27 Full moon is at 4:17 A.M. EST
The moon is at perigee (221,766 miles from Earth), 2:43 P.M. EST

SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
					 1	 2
 3	 4	 5	 6	 7	 8	 9
 10	 11	 12	 13	 14	 15	 16
 17	 18	 19	 20	 21	 22	 23
 24	 25	 26	 27	 28		



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

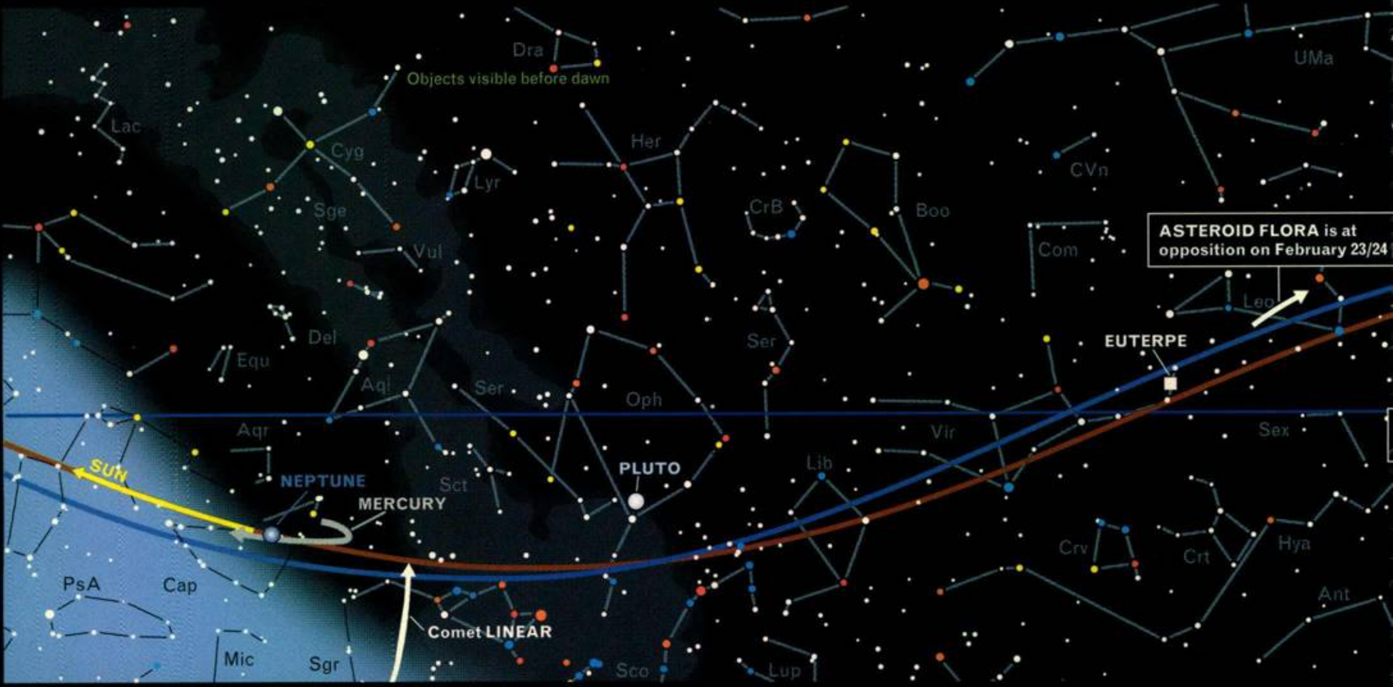

North
West
South
DRACO
CEPHEUS
LACERTA
URSA MINOR
Polaris
NCP
CASSIOPEIA
CAMELOPARDALIS
ANDROMEDA
M31
PEGASUS
URSA MAJOR
Mizar
M81
M82
NGC 869
NGC 884
PERSEUS
TRIANGULUM
M33
LEO MINOR
LYNX
Capella
Algol
AURIGA
M36
M37
M38
Pleiades
ARIES
PISCES
MARS
Castor
Pollux
SATURN
ECLIPTIC
M44
M35
M1
JUPITER
Regulus
CANCER
GEMINI
Aldebaran
Hyades
TAURUS
ORION
Mira
CETUS
CANIS MINOR
Procyon
Betelgeuse
HYDRA
MONOCEROS
M42
Rigel
ERIDANUS
M47
Sirius
CANIS MAJOR
M41
LEPUS
PYXIS
Adhara
PUPPIS
COLUMBA
NGC 2477
CAELUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

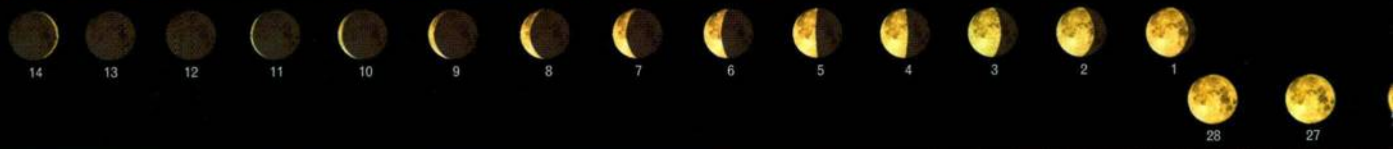
The all-sky map shows
how the sky looks at
10 P.M. on February 1
9 P.M. on February 15
8 P.M. on February 28

Planets are shown
at midmonth

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects d


Dra
Objects visible before dawn
Lac
Cyg
Lyr
Her
Sge
Vul
CrB
Boo
CVn
Com
UMa
ASTEROID FLORA is at opposition on February 23/24
Leo
EUTERPE
Del
Equ
Aql
Ser
Oph
Ser
Vir
Sex
Aqr
SUN
NEPTUNE
MERCURY
Sct
PLUTO
Lib
Crv
Crt
Hya
Ant
PsA
Cap
Comet LINEAR
Mic
Sgr
Sco
Lup


14
13
12
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9
8
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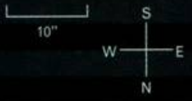
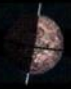
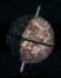
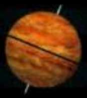
6
5
4
3
2
1
28
27

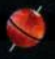
PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITE
Date	February 15	February 28	February 28	February 15	February
Magnitude	0.2	0.0	−3.9	1.2	−2.5
Angular Size	7.8"	6.3"	10.0"	5.1"	43.8"
Illumination	46%	68%	98%	92%	99%
Distance (AU) from Earth	0.860	1.062	1.675	1.834	4.499
Distance (AU) from Sun	0.425	0.464	0.726	1.477	5.188
Right Ascension (2000.0)	20h10.5m	21h04.4m	23h25.2m	1h12.1m	6h25.9m
Declination (2000.0)	−18°43'	−17°39'	−5°17'	7°42'	23°24'





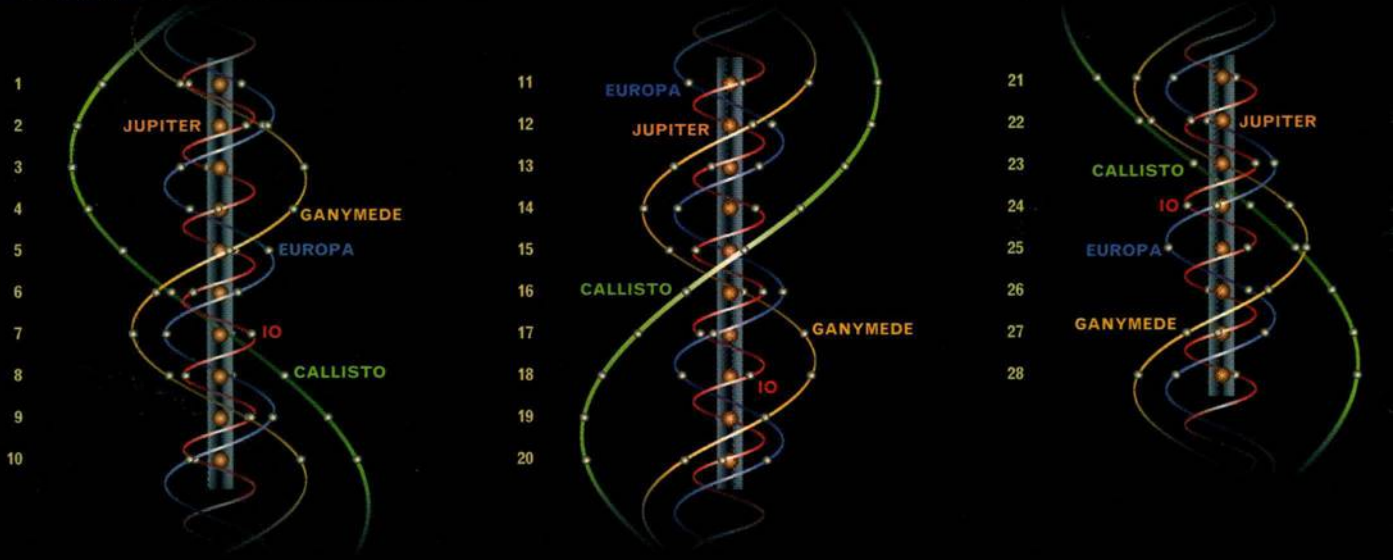




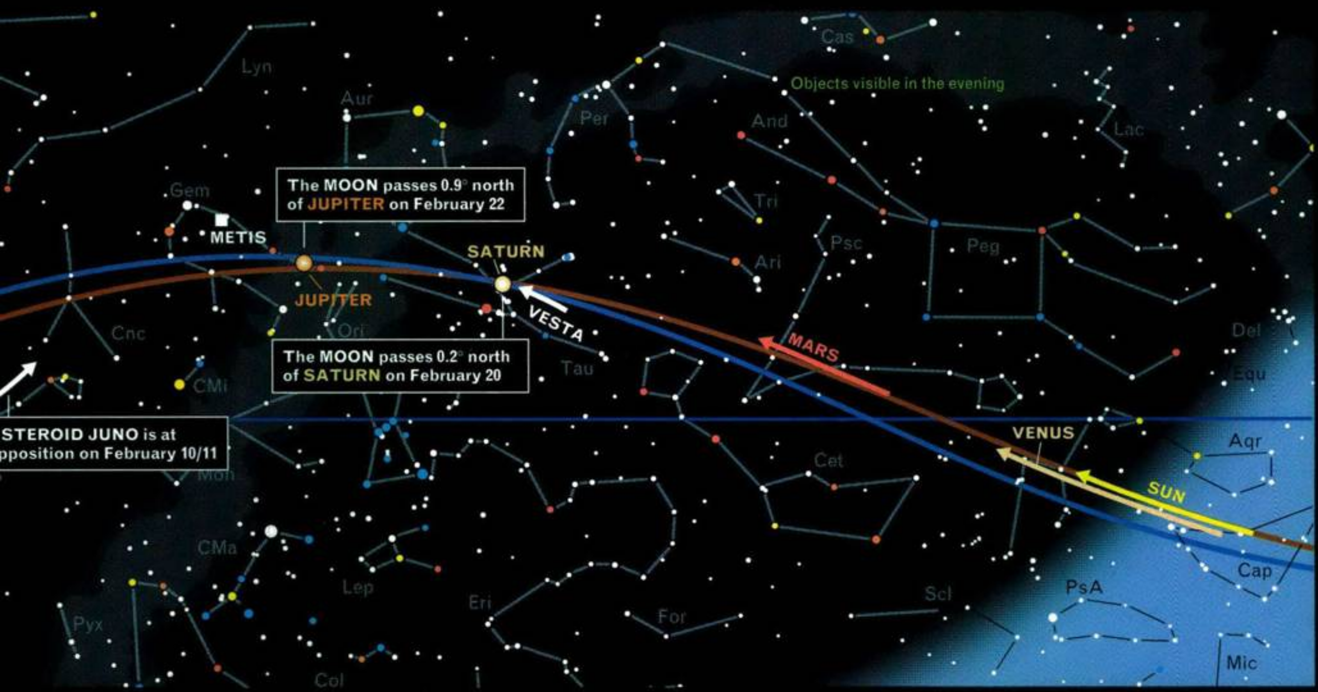


Jupiter's Moons

Dots display positions of Galilean satellites at 10 P.M. EST on date shown. South is at top to match the view in a telescope.



ing the month.

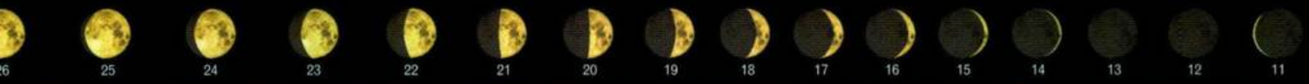

Lyn
Cas
Aur
Objects visible in the evening
Per
And
Lac
Gem
METIS
Tri
SATURN
Psc
Peg
Ari
JUPITER
Cnc
Ori
VESTA
MARS
Del
CMi
Tau
Equ
VENUS
Aqr
Mon
Cet
SUN
CMa
Cap
Lep
Eri
Scl
PsA
Pyx
For
Col
Mic

The **MOON** passes 0.9° north of **JUPITER** on February 22

The **MOON** passes 0.2° north of **SATURN** on February 20

STEROID JUNO is at
pposition on February 10/11

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.


26
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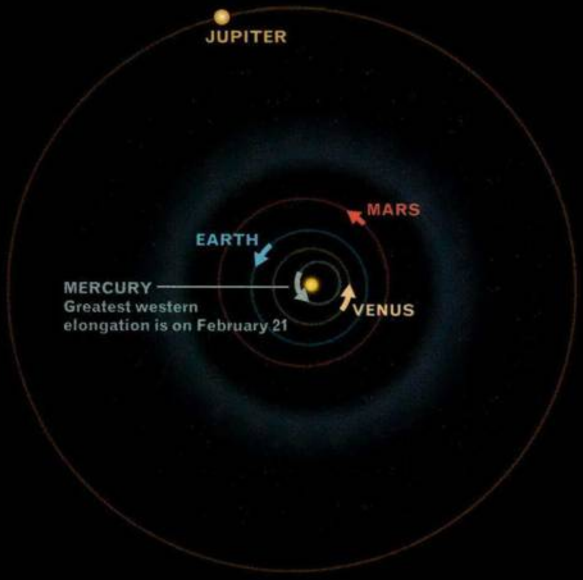
12
11

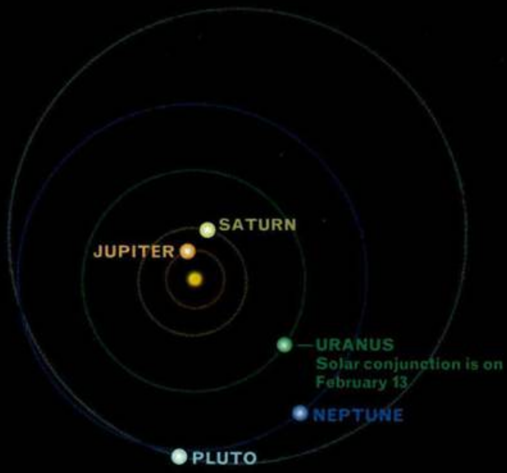
SATURN	**URANUS**	**NEPTUNE**	**PLUTO**
February 15	February 15	February 15	February 15
0.0	5.9	8.0	13.9
18.9"	3.4"	2.2"	0.1"
100%	100%	100%	100%
8.802	20.979	31.038	30.815
9.058	19.991	30.094	30.477
4h26.3m	21h49.6m	20h46.0m	17h08.6m
20°03'	–13°53'	–17°53'	–13°00'

The Planets in Their Orbits

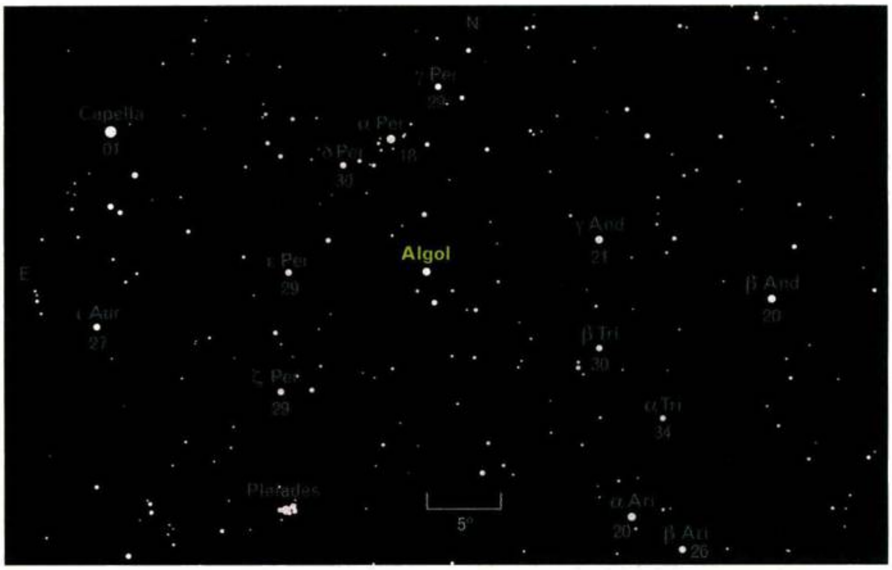
Arrows and dots show planets' positions during the month.

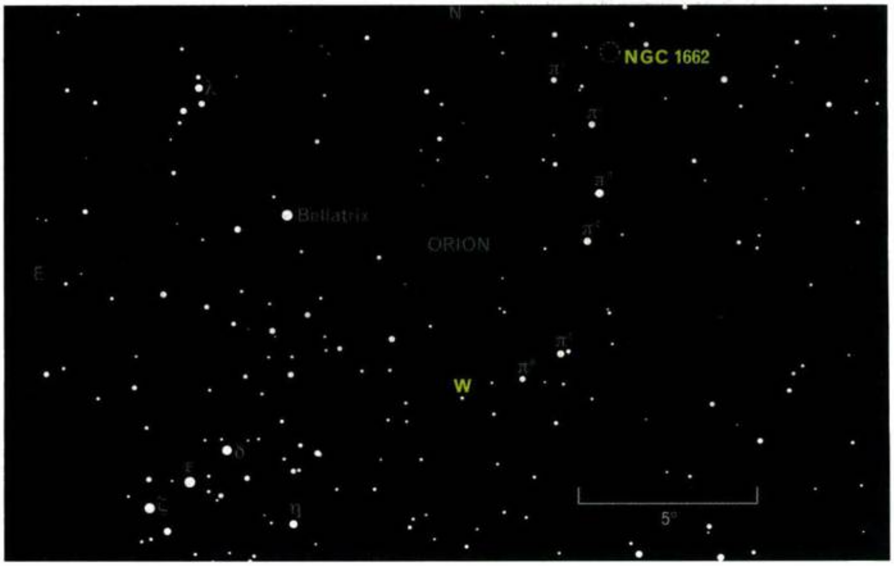

JUPITER
MARS
EARTH
MERCURY
VENUS

MERCURY Greatest western elongation is on February 21


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

URANUS Solar conjunction is on February 13





Clockwork and Chaotic Stars

The ancients typically regarded change in the heavens as a portent of doom. Of course, the universe unfolds oblivious to egocentric humans who are still trying to read meaning into it. Considering that a few cultures figured out the rhythmic pattern of solar eclipses and built structures aligned with the stars, it's a little surprising that the clockwork-like variability of Algol earned it the nickname of the Demon Star. If you pay close attention, you may see it drop a very noticeable 1.3 magnitudes every now and then. If you were fresh out of papyrus or stone tablets, it would be modestly difficult to figure out the periodicity of Algol's 2.87-day cycle. If you were watching the sky the same time every evening, it would take 20 nights before you would see it fade again, and even then, it would be only 1 hour and 40 minutes late. Amazingly, it took 120 years for Renaissance astronomers to nail down Algol's cycle.

It turns out that Algol is a classic "eclipsing binary" — two stars orbiting each other in a tight gravitational dance, at times partially hiding — eclipsing — the other from view. Use the chart and compare Algol's brightness to other comparison stars, whose magnitudes are labeled (with the decimal points omitted for clarity). The Demon Star's normal brightness is about magnitude 2.2.

The best night this month for most North Americans to observe the Demon Star is Sunday evening, February 10. Algol hits minimum brightness at 10:10 P.M. EST (7:10 P.M. PST). The most rapid part of the drop and rise in luminosity is the three hours on either side of this time. The following eclipses are two days, 20 hours, and 50 minutes apart. Annual sky guides such as the RASC's *Observer's Handbook* list all minima of Algol for observing locations all over the world.

W Orionis is definitely not clockwork. It doesn't even "breathe" like the stately Mira stars. No one really knows what is causing this star to convulse so chaotically. Fortunately, its fluctuations are well within reach of binoculars from the backyard. It reaches a peak near 6th magnitude and bottoms out around 8th. W Ori is classified as a semiregular variable, meaning that every pulsation is different in length and depth from any of its previous ones. Its period of roughly 200 days means you're only going to notice a change every couple of weeks.

You can print out a free chart for W Ori from the American Association of Variable Star Observers' website: www.aavso.org. W Ori is a pale but distinct yellow-orange dot compared to the oodles of blue stars that populate this part of the sky.

The winter sky is home to many bright star clusters. Naturally you'll want to see the Pleiades and a string of bright Messier objects. One advantage of star clusters is that from your backyard it's fairly easy to move into the realm of the *New General Catalogue* (NGC) with a small scope. NGC 1662 is a modestly bright grouping of stars at the top of Orion's shield. With my 4.5-inch scope at low power, about 35x, I can see a clump of a dozen stars that stands out well in a relatively barren field. There are three wide pairs, one of which shows a companion at higher magnification of about 130x.

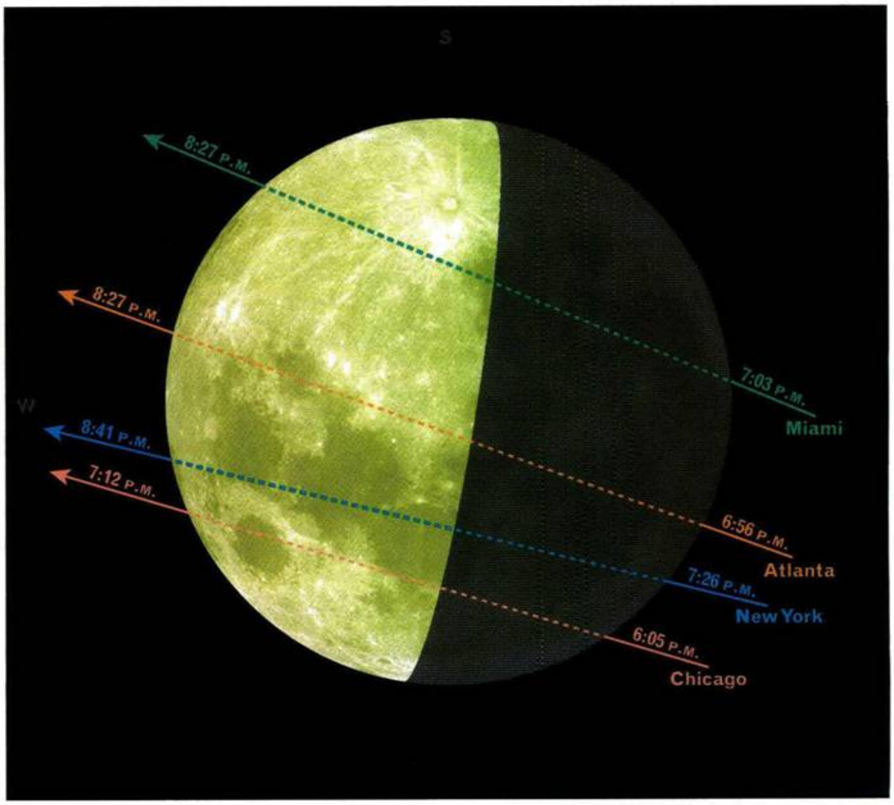
Giant Planets Call for Telescopic Views

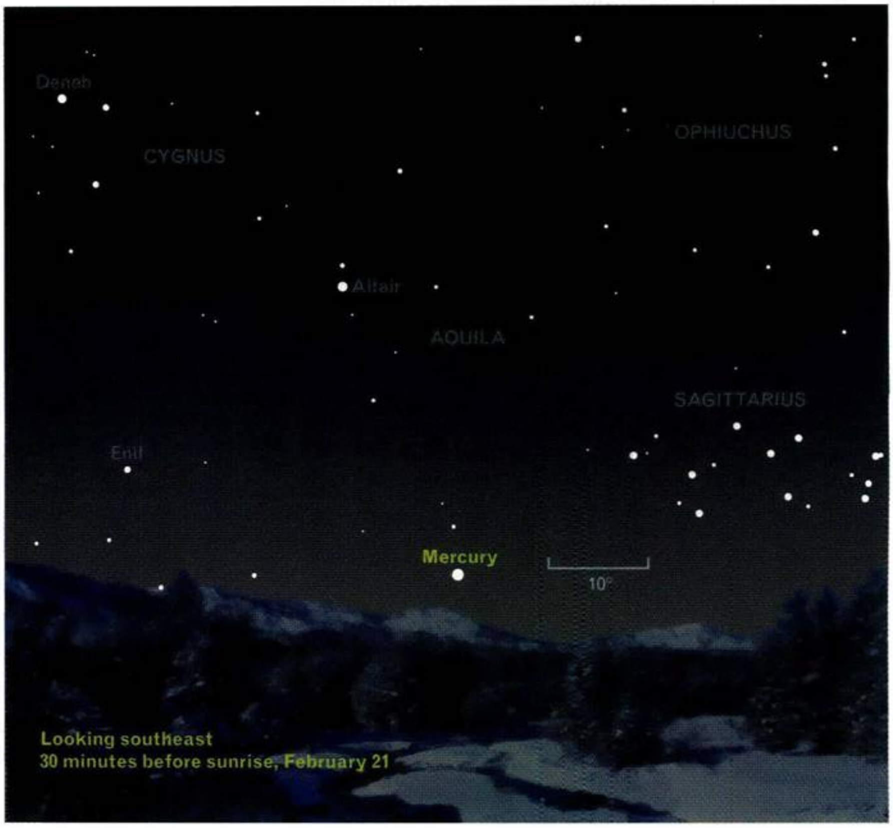
Saturn shines high in the south an hour after sunset while **Jupiter** — at a similar height in the heavens — glows even brighter. So point your telescope skyward to view these planetary gems among an already brilliant set of stars in the winter sky. Make sure you're equipped with a star diagonal, though; your neck will thank you after observing these high-elevation planets.

As you prepare to view Saturn and Jupiter, cast a glance toward **Mars**, which continues to linger in the evening sky. Shining at magnitude 1, Mars spends most of the month in Pisces before moving into Aries in late February. Its tiny disk is rather disappointing when viewed through telescopes. Watch for the Red Planet when it's positioned 5° north of the moon on February 16. By February 28, Mars stands 16° north-northwest of Mira, Omicron (o) Ceti, the ruddy variable star that reached a peak near magnitude 2 last fall.

During the last week of February, **Venus** begins to make its presence known shortly after sunset, although it is just past superior conjunction with the sun. Venus sets 40 minutes after the sun, a time interval that will slowly increase during March. As Mars reduces its elongation from the sun and Venus moves away, the pair will meet in the sky along with Mercury and Saturn during May.

Returning to the main acts of the night, Jupiter and Saturn provide superb planetary sights. To begin with, the moon occults both planets this month. Saturn's occultation, on February 20, is the last one visible from the continental United States until 2014, albeit in daylight for most observers. It's visible along a line from Mexico to San Francisco to the Hudson Bay. The occultation takes place about an hour before sunset. Don't let daylight put you off, though. Finding the moon during the day is easy — if there are no clouds, of course — and picking up the much dimmer Saturn is a breeze after that. American observers on the East Coast will see the event in a dark, early evening sky, while Midwest and west-





Looking southeast
30 minutes before sunrise, February 21

ern skywatchers witness the event in daylight, just before sunset. The reappearance of Saturn from behind the moon takes place approximately an hour after disappearance. However, the event is not visible from most of the northwestern United States.

Two days later, on February 22, the moon hides Jupiter in daylight for observers in Alaska, and in darkness for those in northern Europe and Spain. The rest of mainland United States will have to wait until November 2004 for a similar occurrence. Viewers who see the event will also witness the disappearance of each of the bright Galilean moons of Jupiter just prior to the planet's occultation.

Grab a pair of binoculars to catch Saturn standing near one of the points of the V-shaped group of stars dubbed the Hyades in Taurus the Bull. The view will be spectacular. The planet stands 1° north of Epsilon (ε) Tauri. Typically the Hyades is highlighted by Aldebaran — the reddish-colored magnitude 0.8 star — alone. But Saturn outshines it by almost a whole magnitude and significantly changes the appearance of Taurus.

Any telescope will reveal Saturn's fine set of thin rings, and most will show the thin, dark line separating ring "A" and ring "B." This so-called Cassini Division is a few thousand miles wide. Small telescopes will also reveal Titan, Saturn's largest moon, which shines at magnitude 8.3. Watch it move around Saturn in its 16-day orbit. Titan is the only moon in the solar system with a significant atmosphere, which consists mainly of nitrogen. Curiously, Earth's blanket of air is 72 percent nitrogen.

Jupiter lies near the magnitude 2.8 star Mu (μ) Geminorum. You can't mistake this planet, which is the brightest starlike point in the sky, outshining the brightest star, Sirius, by a whole magnitude. A carefully mounted pair of binoculars may reveal the moons of Jupiter. With a telescope the four major jovian moons jump out at you, as do the two dark equatorial belts that swirl on either side of the planet's equator. Any observer can see these features, but other details require patience. Watch carefully for the all-too-brief moments of good "seeing" — moments when atmospheric turbulence ceases — and you can spot stunning details on Jupiter. You may need to train your eye on the planet for five to ten minutes to see the delicate festoons, plumes, and white and dark spots that define the planet's turbulent nature. Jupiter rotates with dazzling speed. Just imagine — the planet is twelve times larger than Earth, yet spins in less than half the time. It's surprising that Jupiter's atmosphere hasn't flung off into space. You can easily spot the squashed appearance of the jovian planet — its polar diameter is less than its equatorial diameter, indicating that the equator is bulging outward.

Both giant planets are visible until the early hours of the morning. You have to wait until twilight to spot any other planet during February. Darting back and forth to either side of the sun in its rapid 88-day orbit, **Mercury** never stands far from the sun as seen from our earthly perspective. As the innermost planet, also known as one of the "inferior" planets due to its position inside Earth's orbit, Mercury is alternately viewed to the east of the sun in the evening sky and to the west of the sun in the morning sky. In between these times Mercury either passes between the sun and Earth through its inferior conjunction or scoots to the far side of the sun through its superior conjunction. Careful tracking with your telescope will reveal the changing size of Mercury as it moves closer or father away from us during this regular pattern of motion.

Mars shines above the magnificent open star cluster M44, also known as the Beehive Cluster, on May 22, 1978 Mr. and Mrs. Frank Ridolfo

Mercury is a nice challenge for Northern Hemisphere observers this month, because it lies very low in the southeast prior to sunrise. However, it does lie in Capricornus, a region of sky with no other bright stars; so if you see anything in the easterly direction before dawn, chances are it's Mercury. It will only be 5° high 50 minutes before sunrise, and on February 13 it shines at magnitude 0.3. Because the sky brightens so rapidly at dawn, there's only a narrow window to spot the speedy planet. Spending that extra five minutes in the shower in the morning may mean the difference between seeing or missing Mercury. On February 21 the planet will have brightened to magnitude 0, coinciding with Mercury's greatest elongation from the sun of 26°. A few days later Mercury sinks too low to be seen.

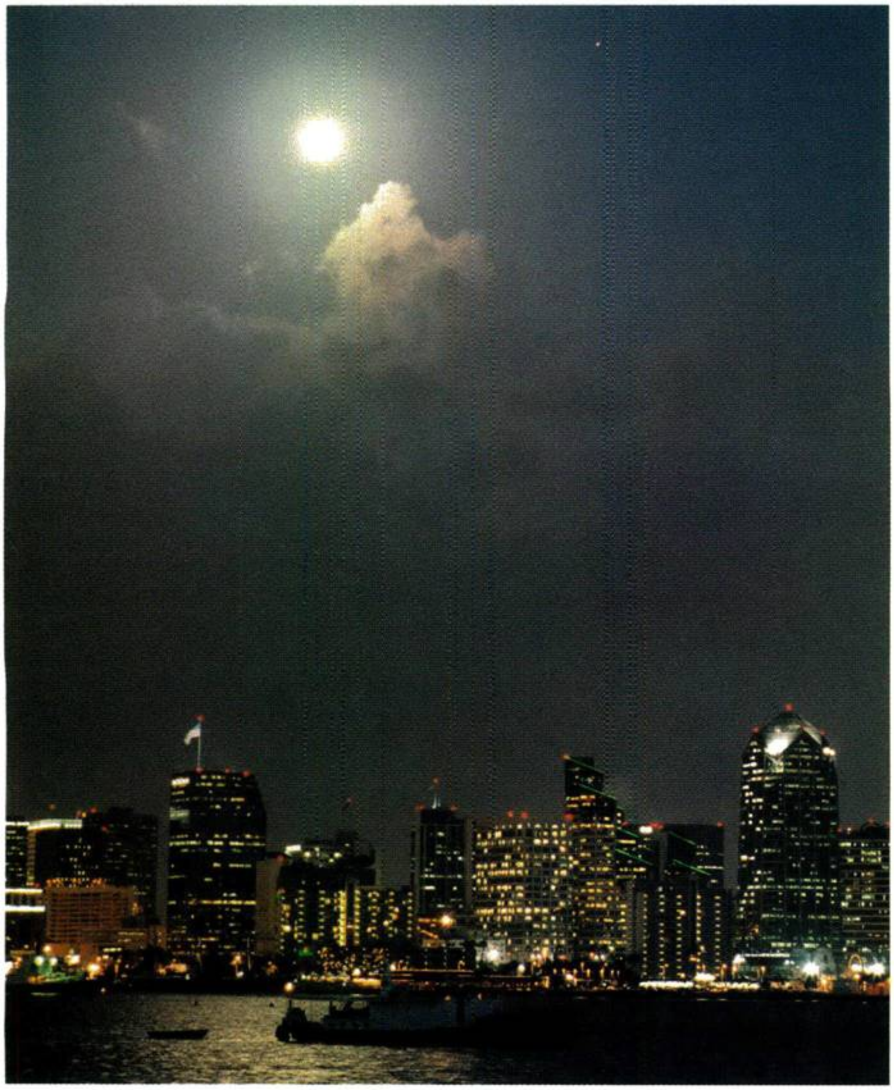
Meteors and Moons

The Full Moon

The full moon is rarely examined through telescopes due to its relatively bland surface and little shadow detail compared with other lunar phases. Yet, closer inspection reveals many fascinating and often overlooked features. On February 27, the full moon coincides with its closest point to Earth, called perigee. This position results in the moon appearing 10 percent larger in our sky than usual, spanning an entire 33'.

Binoculars mounted on a sturdy tripod reveal many features on the fully illuminated moon. Dark spots on the mare regions become evident. Brilliant rays streak across the lunar surface, echoing the drama of ancient impacts. The rays from Tycho are most brilliant — in fact, one of its rays seems to stretch clear across the entire lunar face. The rays emanating away from Copernicus are also spectacular, and the stunning bright splash feature around the crater is visible in telescopes. Look also for the dark splotches around Copernicus — features that are much darker than the surrounding maria (lunar seas).

Below: The moon and a remote Mars shed some light on the Miami skyline. Peter Ward



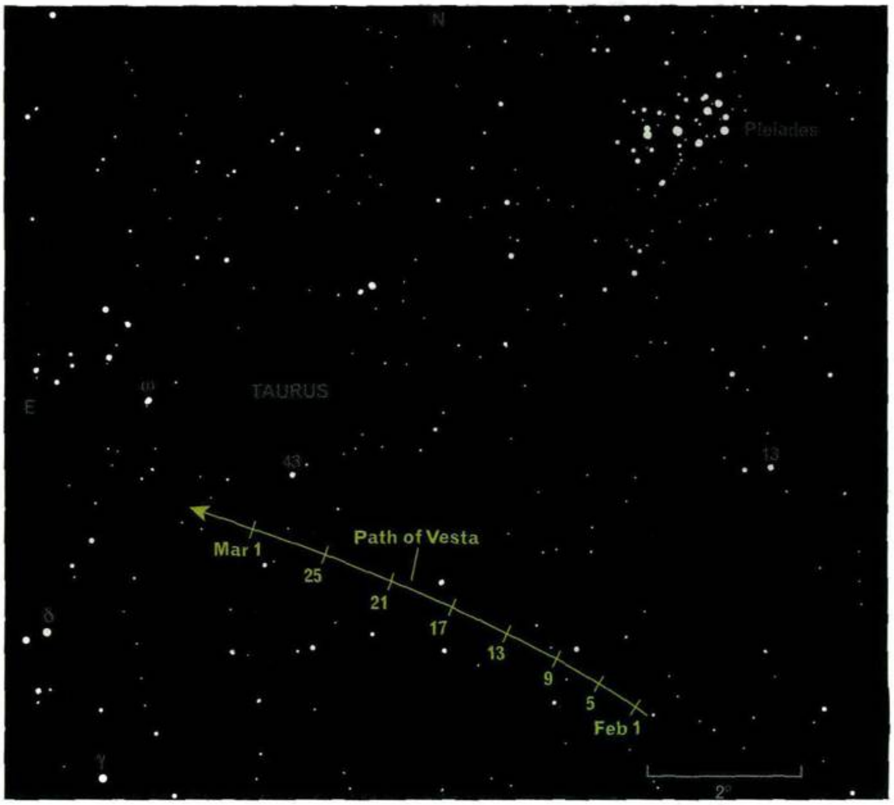
Jupiter's Satellites

The rare events involving occultations, transits, and eclipses of Jupiter's fourth largest moon, Callisto, continue this month. During each orbit of Jupiter around the sun (12 Earth years), only two series of eclipses involving Callisto occur. Below is a table of events, given in Universal Time (GMT) and Eastern Standard Time (EST). Events that occur on either side of midnight are shown twice, since the date changes for observers in Europe or the United States. Two eclipse sequences and two transits occur in February. The events listed below are given in Eastern Daylight Time. Tr = Transit; I = Ingress; E = Egress; Oc = Occultation; Sh = Shadow Transit; Ec = Eclipse; D = Disappearance; R = Reappearance. The events are worth viewing due to their relative rarity. Not all are visible from the United States.

Jupiter shines along with some of its tightly held satellites. Fred Johnson

Callisto Events for February 2002

	UT	EST	
Feb. 7	22:07	17:07	IV.Oc.D.
	19:51	IV.Oc.R.	
Feb. 8	00:51	IV.Oc.R.	
	06:13	01:13	IV.Ec.D.
	09:22	04:22	IV.Ec.R.
Feb. 16	07:42	02:42	IV.Tr.I.
	10:25	05:25	IV.Tr.E.
	17:01	12:01	IV.Sh.I.
	20:13	15:13	IV.Sh.E.
Feb. 24	13:51	08:51	IV.Oc.D.
	16:39	11:39	IV.Oc.R.
	19:16	IV.Ec.D.	
	22:35	IV.Ec.R.	
Feb. 25	00:16	IV.Ec.D.	
	03:35	IV.Ec.R.	



Asteroid Vesta soars through Ophiuchus over a three day period in 1978. Tom Cihak

LINEAR WM1 Puts on a Morning Show

There's a special place in everyone's memory for seeing a comet with the naked eye. WM1 LINEAR, which should now be visible without optical aids, puts on its best show in the last week of February, when the interfering moon is out of the way. You'll need to set your alarm for about 6 A.M., and binoculars will help you locate it low near the horizon, about two binocular fields (12°) to the right of where the sun rises.

At 6th magnitude, the comet will be fighting a bit to shine through any haze trapped low in the sky. To see much of its tail, your best bet is to view under dark rural skies. The tail should stretch off to the upper right.

Despite its gradual fade next month, WM1 LINEAR will be easier to find because it will soar higher in the sky, not far from the bright star Altair. Last summer's A2 LINEAR brightened three magnitudes unexpectedly, so you never know for sure what you might see.

Asteroid 4 Vesta in Binoculars

Perfectly placed high in the evening sky, Vesta lies just a little more than one binocular field below the magnificent Pleiades star cluster. The giant space rock is dubbed Vesta 4 because it was the fourth asteroid ever discovered. Vesta, first observed in 1807, also happens to be the third largest member of the known asteroid family. From your balcony or backyard you can follow Vesta's motion against the background stars every few evenings.

At magnitude 7.8, Vesta is bright enough to punch through most city light domes. As you can see on the chart, this asteroid threads a nice line between several 6th- and 7th- magnitude stars. For fun, mark Vesta's position on a sketch of the field so you can make a record of its path. Next month the asteroid will pass only 10' (1/3 the apparent size of the moon) from Saturn.

Interestingly, Vesta has a reflectivity, or albedo, of 38 percent — about the same as Earth, which is about seven times more reflective than the moon. The dust that's covering it must be finer and whiter than that on Ceres, because asteroid 1 Ceres has an albedo of only 10 percent.

Vesta has been battered by collisions with other space rocks for eons, so much so that its now partly fragmented surface has allowed astronomers using the Hubble Space Telescope to probe the asteroid's inner geology. Interestingly, the composition of some meteorites collected and analyzed here on Earth show a striking similarity to the geological makeup of this asteroid. This fact has made Vesta 4 only the fourth solar system object, along with Earth, the moon and Mars, from which scientists have a confirmed laboratory sample.

Lastly, Asteroids 9 Metis and 3 Juno are both brighter than 10th magnitude this month. ■

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

Do Computerized Telescopes Enhance the Learning Curve for Amateur Astronomers or Substitute for Celestial Knowledge?

? NOT

THAT IS

Coke or Pepsi? Butter or margarine? Sometimes it pays to count our blessings that we can still ponder these seemingly vapid subjects with passion. Yet passion drives many amateur astronomers — who sometimes display an almost religious devotion to their equipment and observing methods. For them, the question remains: Go-to or not?

Thanks to computerized star coordinates, beginners no longer need to study the sky before finding the cool stuff. They just punch in some numbers and the telescope locates the objects for them. Even experienced observers often embrace this convenience. But should it be this easy? How about the intrinsic value of learning the sky? And what are the implications for the hobby of astronomy? Let's listen in as two experienced amateur astronomers duke it out regarding the merits of Go-to technology.

No: by Steve Edberg

In a perfect world, a beginning astronomer starts with the recommended binocular observing sessions under the watchful eyes of an experienced observer or while at a star party, and gradually eases into telescopic observing. In reality, this is seldom the case: Most beginning observers initially use their new telescopes at home — without assistance.

TO "GO-TO" OR TO "GO-TO"?

THE QUESTION.

A beginning astronomer who rushes outside with a manual telescope and planisphere likely experiences some initial frustration. He or she also finds that stars still appear as pinpoints through a telescope, that the moon looks really neat but is too bright for comfort, and may even note a star that's not on the chart — instead, it's a planet. And so a night starting with minor frustration ends in triumph: The new observer is excited and has not only learned some of the sky, but also how to move and point the telescope. He or she probably can't wait to do it again.

With all the Go-to telescopes now available, however, it's fair to say that many beginners will prefer a computerized telescope control system that finds objects at the press of a button (and sometimes by voice command). I have used these, and they increase my observing efficiency several-fold — once I get past the initialization procedure from the often poorly written computer manual. After the telescope's computer is running, I find objects faster, which saves more time for observing — instead of searching for — stellar objects.

All this is fine for a moderately computer-savvy observer with more than three decades of starhopping. But what about the newly minted astronomer out for the first time with a new, gee-whiz-bang computer-controlled wonder telescope?

Our beginner is due for a rude awakening. Instructions that were read in the light of day become much harder to read by flashlight. Questions arise: What does azimuth mean? Latitude and longitude are necessary? Where do I find them? Is my watch correct? Is that the right set-up star? He or she also soon discovers that pushing buttons while wearing gloves is difficult in the cool night.

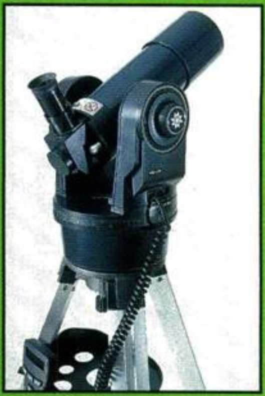
Finally, the telescope is up and running. First object — pick a number, say seven. Program in "Go-to NGC 7." Nothing happens. Try "Go-to NGC0007." It's below the horizon. Oh well. How about M57? "Go-to M57" . . . Whirr . . . Buzz . . . All quiet. Our astronomer sees stars — lots of them. So which one is M57?

It turns out that M57 is sometimes just outside the field of view. Unfortunately, the beginner doesn't try scanning the sky to find the object — which is too faint to be seen with this particular telescope anyway, especially by an inexperienced observer in bright, urban skies. So our brand-new astronomer begins a new hobby with frustration, as did the user of the manually controlled telescope.

The difference is that when both observers reach some level of proficiency, one will have learned how to locate celestial objects and will understand some of the capabilities of a

Celestron's 5-inch Schmidt-Cassegrain holds its own in any contest between computerized and manual telescopes.

Astronomy: Bill Zuback



Astronomy: Jim Forbes

The Meade ETX-60AT model rates among the best of the computerized Go-to telescopes on the market.

manual telescope, while the other will only know how to run a computer-controlled telescope. Who would you rather have as an ambassador for our hobby? Someone who can point out constellations, stars, and planets, as well as find a few showcase objects by memory? Or someone who sets up a "wonder" telescope but can't point out Scorpius and Antares? A computer helps a beginner aim a telescope, but he or she can't tell the audience why any particular star should stand out. Imagine what will happen when our computer-savvy observer's telescope batteries fail or if the neighbors ask the beginner to point out a zodiacal sign.

In addition to sharing a sky tour with friends and strangers, a beginner who learns the sky experiences an inner sense of joy and accomplishment in acquiring new knowledge. Go-to telescope systems may make it easier for newcomers to get started in our hobby, and even the *Wall Street Journal* notes that one still has to learn things to use a computerized telescope. But Go-to systems don't provide the knowledge of the sky that the starhopper acquires as he or she makes associations, learns constellations, and invents shortcuts to locate favorite objects.

Just as neophyte drivers learn to navigate their neighborhood without a map, so too should beginner astronomers develop a basic knowledge of where things are in the sky and how to find them. Don't be an astronomer who can't locate the Big Dipper without a computer. Your appreciation for the universe will grow as your observing skills increase.

Steve Edberg has been pushing and pulling his telescope around the sky since the 1960s, before anyone had imagined privately owning a computerized scope.

Yes: by David Healy

Go-to capability is now so commonplace that star parties echo with the buzzing, whining, and grinding noises of telescopes effortlessly slewing to everything from the Ring Nebula to the most obscure galaxy in the *NGC*. As far as the debate between observing "purists" and computer users goes, I'll weigh in with the side favoring Go-to observing. Here's why:

In amateur astronomy, the starhopping advocates' best argument is that over-reliance on push-button astronomy robs observers of knowledge and appreciation of the sky. I say that there are two ways to learn and appreciate the sky, neither of which involves teetering on the end of a twelve foot ladder using one hand to hold the star chart, one hand to hold the flashlight, one hand to push the telescope, and one hand to cling to the ladder.

The first excellent way is to lie on your back on a lounge chair and gawk. After awhile, you might become curious about the name of a peculiar star cluster, a bright red star, or a distinctive star pattern. Without moving from your chair, you can look at your planisphere or a sky manual and satisfy your curiosity.

If you wish to learn the sky by starhopping, it is, in my opinion, far more fun and productive to do so with a good pair of binoculars than with a manually operated telescope. A binoculars' wide field of view allows you to run across interesting objects you've never seen before — and then with the help of a good star chart, identify your discoveries.

But I digress. A Go-to scope lets the observer spend far more time actually observing deep-sky targets and far less time in tedious searches. The Go-to observer punches up every globular cluster currently above the horizon, and, in a matter of a few minutes, compares their sizes, star concentrations, and brightness. Or, that same observer can examine a list of showpiece double stars.

For the experienced observer, a Go-to telescope accomplishes hardcore observing challenges that would be difficult or impossible by starhopping. Last year, for instance, I observed in the dense central group of galaxies in the constellation Virgo, examples of each of the major galaxy types in the Hubble sequence: ellipticals, lenticulars, Sb spirals (both edge-on and face-on), barred spirals and irregulars. The Go-to scope allowed movement among the various types with no interruptions for searches. The telescope's precise centering of each target left no doubt, even in that crowded field, what galaxy I was looking at. And since I was able to observe all these galaxies while seated at the eyepiece, I was able to preserve full dark adaption without interruption.

If I had been trying to observe that same Hubble sequence with, say, a large Dobsonian telescope, it's very likely I would have lost some dark adaption to stray ambient lights or even light from my flashlight shining on a star chart when I got up to move the telescope. The preservation of full-dark adaption made it possible, with my Go-to scope, to see faint galactic structure — spiral arms, halos, dark lanes, and even a jet of material being ejected at relativistic speeds from the nucleus of a giant elliptical galaxy.

So I come down on the side of Go-to observing, chiefly because I can observe more deep-sky objects — both showpieces and challenges — than I can by manually starhopping. And beginners can still learn the sky — with a good sky manual and a lounge chair.

David Healy's series on astrophotography appeared in the June 2000 issue of Astronomy.

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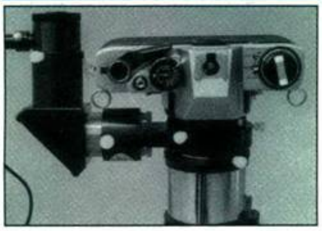

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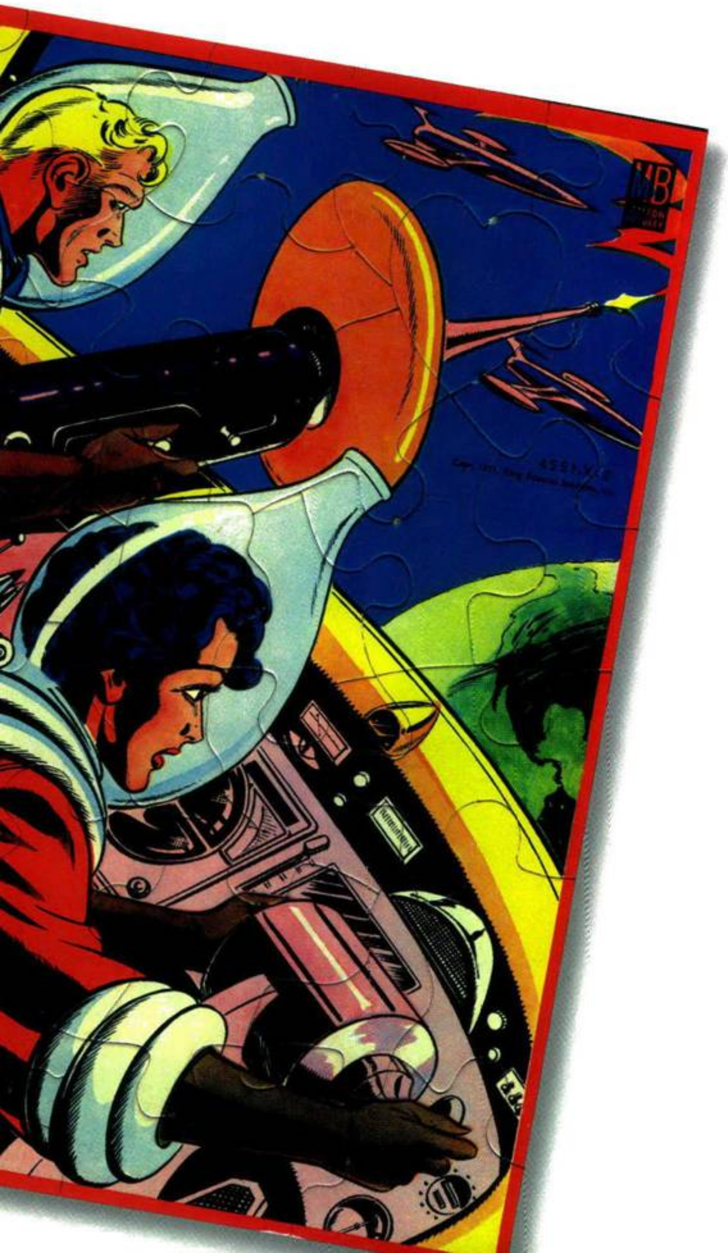
collecting SPACE

In This Issue:
THE RAIN OF TERROR!
JET
S.R.P.-2
OFF ON

REX MARS
ROCKET FIGHTER

STUFF

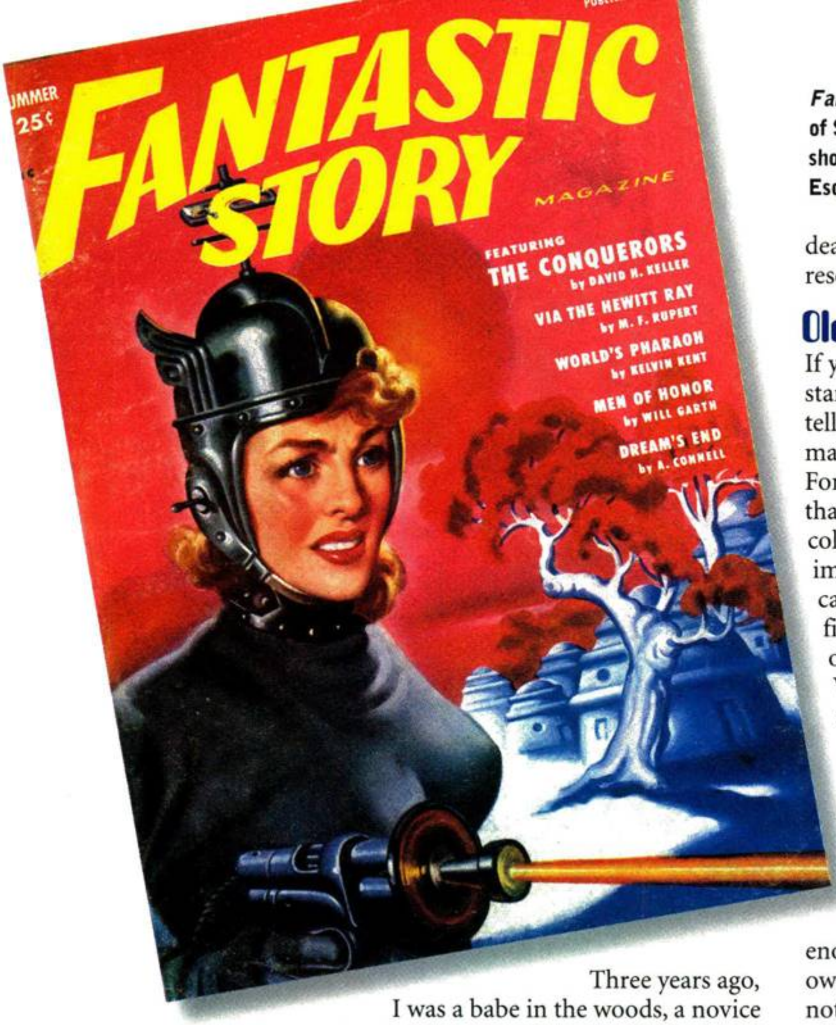


Warning! Collecting Mars rovers, space stamps, astronaut autographs, or children's astronomy books may grow into an addiction.

by Nancy L. Hendrickson

On the shelf between Mr. Spock and my Mars Rover sits a piece of astronomical history — a replica of the Hale Telescope's 200-inch mirror. Issued by the Corning Glass Works as a 1939 World's Fair souvenir, the 3½-inch memento is part of my growing collection of astronomy and space memorabilia. This collection, I must admit, was born more from a love of toys than building a wide-based investment portfolio. The serious collector never cracks the plastic on his purchases. My Mars Rover runs rampant.

Images on this page are courtesy of "Blast Off," an exhibition currently at the Museum, California Center for the Arts, Escondido. Lavender Robot from "The Gang of Five," Masayuda, late 1950s (left), is from the collection of Tom Brannan. *Jet* comic book cover, No. 4, 1951 (center), is from the collection of Vincent Zurzolo. Flash Gordon jigsaw puzzle, Milton Bradley, 1951 (right), is from the collection of Rick Jones. Rex Mars Fighter, Louis Marx, 1950s (above) is from the collection of Rick Jones. Photos by Julius Lopes, Chris Horn, S. Mark Young.



Fantastic Story magazine cover, early 1950s is from the collection of S. Mark Young. It was provided to us by the organizers of the current show "Blast Off" at Museum, California Center for the Arts, Escondido. Photo by Chris Horn

Three years ago, I was a babe in the woods, a novice collector who could have walked past Edwin Hubble's pipe without a backward glance. I knew I liked space-related relics, but didn't realize they're collected as ardently as Elvis souvenirs. All that changed the day I walked into a Carlsbad, California, antique shop, saw a fire-engine red Tom Corbett Space Cadet lunch box and asked, "How much?" "Three hundred," the owner replied. Gulp.

In the years since, I've talked to other collectors, researched the field, and acquired a few choice pieces via eBay, an online auction site. I've discovered that astronomy and space collectibles can be had for less than a buck or as much as $50,000. Some of what's collected will surprise you, some won't. And some will turn you green because, as a kid, you once owned them. If you want to collect too, here's how to get started.

Am I the only one who's dreamed of stopping at a yard sale and finding an Alvan Clark refractor peeking out from under a pile of old baby clothes? Well, don't get your hopes up. Clark scopes do exist. Finding an available one is another story. Ken Launie, a founder of the Antique Telescope Society, says a Clark will occasionally come up at antique auctions but they're quickly snapped up. The competition is fierce and the price is high — a minimum of $1,000 per inch of aperture. Maddeningly, you may be competing against a dealer who's buying the scope for "the look," with plans of reselling it to a client who wants it simply for decor.

Old Robots and Space Toys

If you're not set on a Clark, but want to get your collection started with an antique instrument, *caveat emptor*! Launie tells of a number of bogus reproduction telescopes on the market that the sellers themselves believe to be originals. Fortunately, there are older, unsigned refractors available that start at only a few hundred dollars. For the serious collector, knowing the originality of the optics is just as important as the authenticity of the scope itself. The value can drop to half in a scope with replacement optics. Some fine old instruments will appear in antique stores, online on eBay, and at other auction houses. Occasionally Vernonscope holds auctions for antique scientific instruments (look for its ad in *Astronomy*); auction houses like Christie's and Sotheby's are other possible sources. If your heart is set on a piece of optical history, join the Antique Telescope Society, educate yourself, and network like crazy.

Don't give up on yard sales for other treasures, though. It's possible you'll find a space toy worth enough to pay for that antique refractor. If you're old enough to remember Flash Gordon, here's wishing you still own his Space Car. It'll cost you $400 to replace. But that's nothing compared to the tin robots made by Japanese companies back in the 1950s. Masudaya Company's Gang of Five sell today for more than $5,000 each; at auction, one of them went for $42,000. Gang of Five robots were battery-operated and distinctively designed characters called Sonic Robot, Lavender Robot, Machine Man, Target Robot, and Radicon Robot. Bill O'Neill of "Robots and Space Toys" will happily sell you the recently released reproduction set.

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From the author's collection: Lavender Robot; Cosmic, the secret messenger set; and the Golden Record _Rocket to Mars_. Photo by David Cortner.

ROCKETS AWAY
Sensational Space Travel Game
SPACE STATION

Rockets Away board game, Amosco, 1952, is from the collection of Rick Jones. The game is part of the "Blast Off" exhibition being staged in Escondido, California. Photo by Rick Jones.

A collector himself, Bill caught the bug early, thanks to growing up with Japanese friends who preferred Godzilla over Superman.

Hot Wheels Mars Rover

Like buying antique telescopes, buying old robots can be a tricky business; reproductions are passed off as vintage items. Robot-guru Brian Hayes of the United Kingdom has an extensive robot Internet site which includes articles on rating a robot's condition and making smart buys. According to Hayes, the current robot popularity is due to a nostalgic look back at the 1950s space movies, Sputnik, and the moon landing. "The people who were brought up in that apparently cozy climate are now financially secure enough to pour some of their money into space toys."

Buying a reproduction can be a less expensive way to build your collection. Plus, in another 40 years the reproductions will be considered vintage. The current Japanese reproductions are considered by some dealers to be better made than the originals, and a vintage robot that sells for more than $1,000 can be picked up in repro form for $25.

49¢
FORM
CUED!
LLITE
RVED!

One of the most recent hot astronomy toys is Mattel's Hot Wheels Mars Rover. After the Pathfinder landing, the Jet Propulsion Laboratory store in Pasadena, California, sold out of 1,500 Action Packs in 20 minutes. "We could have sold 5,000," said store manager Mark Banuelos. Mattel's Sara Rosales said the Mars package was the first toy the company had done as an authentic replica. Mattel even sent Hot Wheels designers to JPL to make certain all the details were perfect.

The joint JPL-Mattel venture was such a success they teamed up for another go-round with the Hot Wheels Jupiter/Europa Encounter Action Pack. Good luck finding one of those in Toys 'R Us. The Mars Rover is sitting on my shelf only because I was the successful bidder online.

What You Can Get for Under a Buck

Remember those collectibles I mentioned that cost less than a buck? You won't have to go to auction to find these — they're sitting behind the counter at your local stamp store. If you haven't collected stamps since you were a kid, you may not know that philately is more specialized than ever. Instead of collecting by country, many hobbyists now collect by

NANCY'S SECRETS FOR WINNING AT AN ONLINE AUCTION

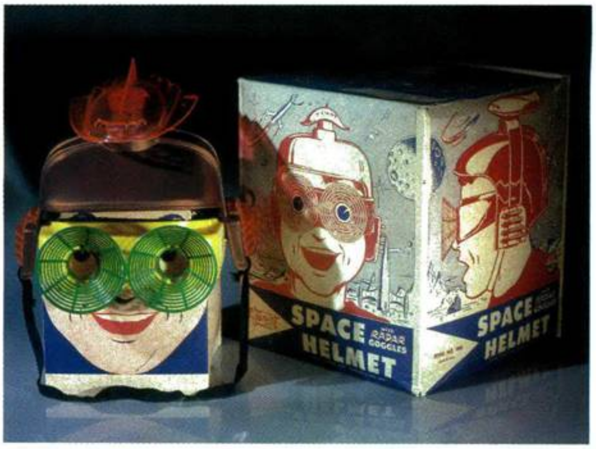
The difference between an auction house and its online cousin is timing. In an auction, bidding continues until no one is willing to bid any higher. Online, bidding is over at a pre-specified time. If the clock says the final drop of the cyber-hammer will occur at 18:23:24, that's when it ends, no matter how many people are willing to pay more. The secret is in placing your high bid so close to the final second that no one has enough time left on the clock to place another.

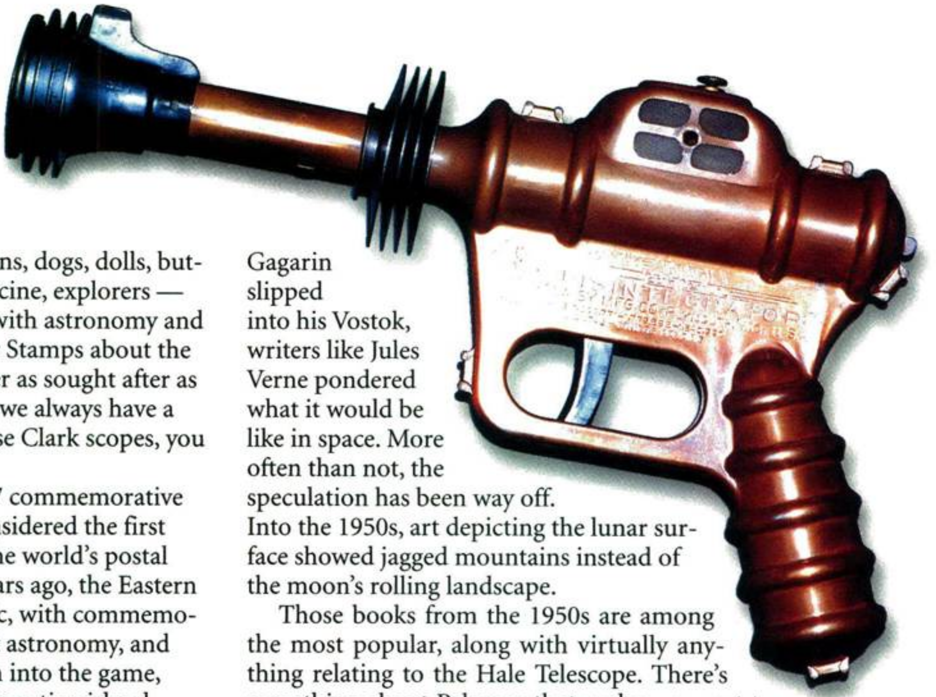
At eBay, the Internet's premiere auction site, you'll be up against some savvy bidders. They'll pick out which auctions to bid in, but they'll rarely place a bid until the final seconds, even though the item has been on the block for a week. They don't want you to know they're interested. Then, when you think you've easily won your treasure, a last-second bidder will swoop down and beat you.

To be a successful eBay bidder, prepare your highest bid in the minutes before the auction closes, but don't submit the final bid page. Next, minimize your bid page and open a second window that you can keep reloading in order to keep track of the auction clock and watch for any last-second bids coming in. Now here's the gutsy part. Wait until only a few seconds remain on the clock before you submit your bid. This takes a cool head and a steady hand, along with split-second timing. But be careful — the eBay system may have thousands of bids going on at the same instant as yours, so if you wait too long, there's a chance the system can't process your bid and the auction will be closed before you're off the launch pad. Some bidders have three windows going: two with bids, one to keep reloading the time.

Practice on low-cost items just to get the feel of the system. You don't want to be a novice bidder the day the Clark scope hits the block.

Banner Space Helmet with Radar Goggles, 1950s, is from the collection of Rick Jones, and currently in the "Blast Off" exhibition. Photo by Rick Jones.



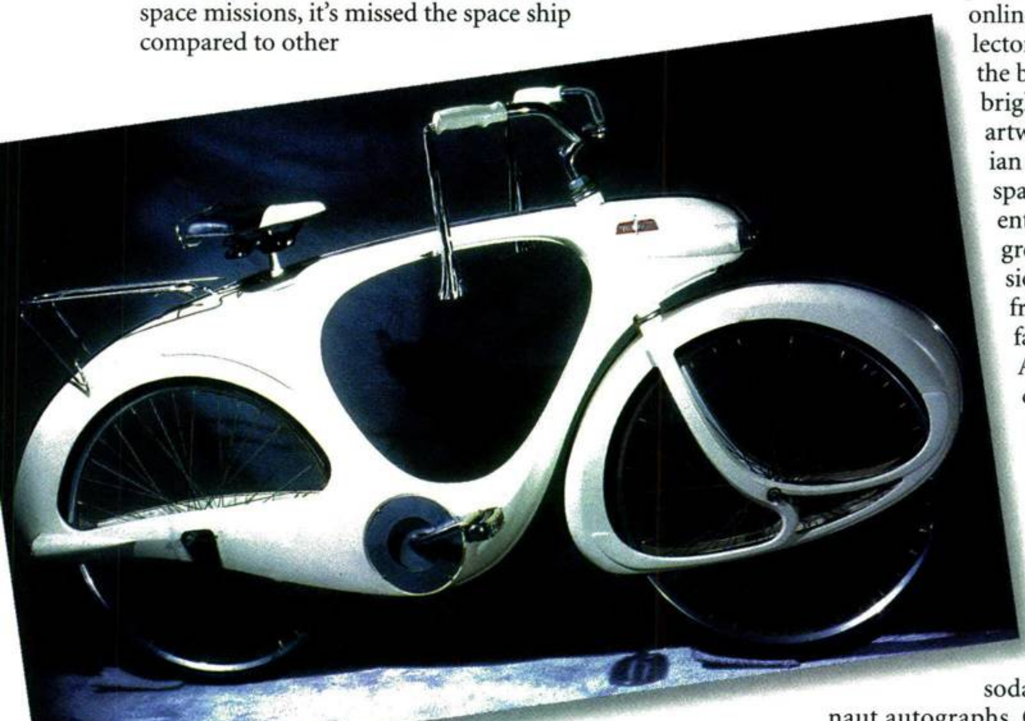


Buck Rogers Disintegrator Pistol XZ38, Daisy, 1936, from the collection of Rick Jones. Spacelander Bicycle, 1960, (below) is from the collection of Justin Pinchot. Photo by Charles Jones, Wayne Jagielski.

special interests. Tropical fish, robots, trains, dogs, dolls, butterflies, waterfalls, horses, airplanes, medicine, explorers — all have become niche collectibles. Ditto with astronomy and space. I asked Mary Rathbone of Kei-Mar Stamps about the popularity of space stamps. "They're never as sought after as the latest fad stamps like Princess Di, but we always have a steady market for them." And, unlike those Clark scopes, you can buy a collectible stamp for two bits.

The United States Postal Service's 1947 commemorative stamp depicting the Hale Telescope is considered the first space stamp. Since that Palomar stamp, the world's postal services have gone space crazy. Several years ago, the Eastern European countries were the most prolific, with commemoratives touting big Russian rockets, Soviet astronomy, and Sputnik. More recently, everyone's gotten into the game, with some of the most colorful coming from tiny island nations like Palau. Their souvenir sheet depicting Edwin Hubble and the 1993 and 1997 Hubble servicing missions are breathtaking. And the whole set sells for under $15.

Although the USPS has issued Shuttle commemoratives, a Mars Pathfinder sheet, and stamps that honor a few other space missions, it's missed the space ship compared to other countries. A small sampling of international issues include Australia's commemoration of the International Space Year, with stamps picturing the Helix Nebula, Pleiades, and spiral galaxy NGC 2997; Micronesia, Sri Lanka, and British Antarctic Territory's Halley's Comet, Mongolia's history of space exploration, and Nicaragua's sheet of famous astronomers and their telescopes. For the collector on a budget, stamps will give you more bang for your buck.



Old astronomy and space books are a bit more expensive than stamps, but most often under $100. Decades before Yuri Gagarin slipped into his Vostok, writers like Jules Verne pondered what it would be like in space. More often than not, the speculation has been way off. Into the 1950s, art depicting the lunar surface showed jagged mountains instead of the moon's rolling landscape.

Those books from the 1950s are among the most popular, along with virtually anything relating to the Hale Telescope. There's something about Palomar that makes us want to own a bit of it. The good news is that these frequently come on the market at a reasonable price. Try online and used bookstores.

A sub-niche in the book market is children's space books, particularly ones from the 1950s. I've witnessed online auction shoot-outs between several collectors all gunning for the same book. Part of the books' charm is their naiveté about our bright future in space, while part is the retro artwork. John Sisson, biological science librarian at University of California, Irvine, and space artist Alexa Smith, are two of the most enthusiastic collectors in the field. Sisson grew up a block away from the Jet Propulsion Laboratory. When his grade school friends brought in photos from their father's missions, he was instantly hooked. As an adult, Sisson began collecting children's books on space flight, and his web page is a tribute to the images that inspired a generation. Smith collects children's space books from the 1800s to current time. "I love the illustrations and stories, and they compile a history of the space program."

Space holds us in its grip, no doubt about it. We clamor to own even a speck of it. Baking soda-propelled rockets, astronaut autographs, Gilbert telescopes, solar system clocks — the objects we collect are as varied as the stars themselves. On the advice of an antique dealer, I buy only what I truly love. For Ken Launie, that may be historic glass, for Smith, a mint copy of the *Little Golden Book of Exploring Space*. And me? I want a moon rock. ◼

Nancy Hendrickson, of San Diego, is a freelance writer. Look for "Blast Off" exhibition story at Astronomy.com.

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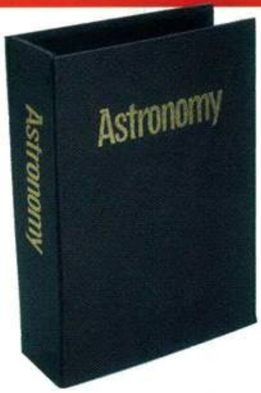

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Monoceros and Pyxis

Sparkling clusters and stunning nebulae make these inconspicuous constellations a backyard observer's delight.

by Tom Polakis

The often frigid evenings of winter do have one saving grace: The sky saves its brightest stars of the year for our observing pleasure. Tucked inside the triangle formed by the familiar stars of Orion, Sirius in Canis Major, and Procyon in Canis Minor, lies the barely distinguishable constellation Monoceros the Unicorn. Holding only three stars brighter than magnitude 4.0 and with the nearly uniform mist of the Milky Way running through it, Monoceros ranks among the most difficult constellations to pick out.

Although much smaller, the constellation Pyxis the Compass proves easier to spot. Look 20° east of the hind legs of Canis Major to spy three 4th-magnitude stars in a line. The brightest of these, Alpha (α) Pyxidis, shines with the light of nearly 2,000 suns — it appears faint only because it lies more than 800 light-years from Earth. Pxyis resides on the fringe of the Milky Way and contains open clusters, nebulae, and galaxies.

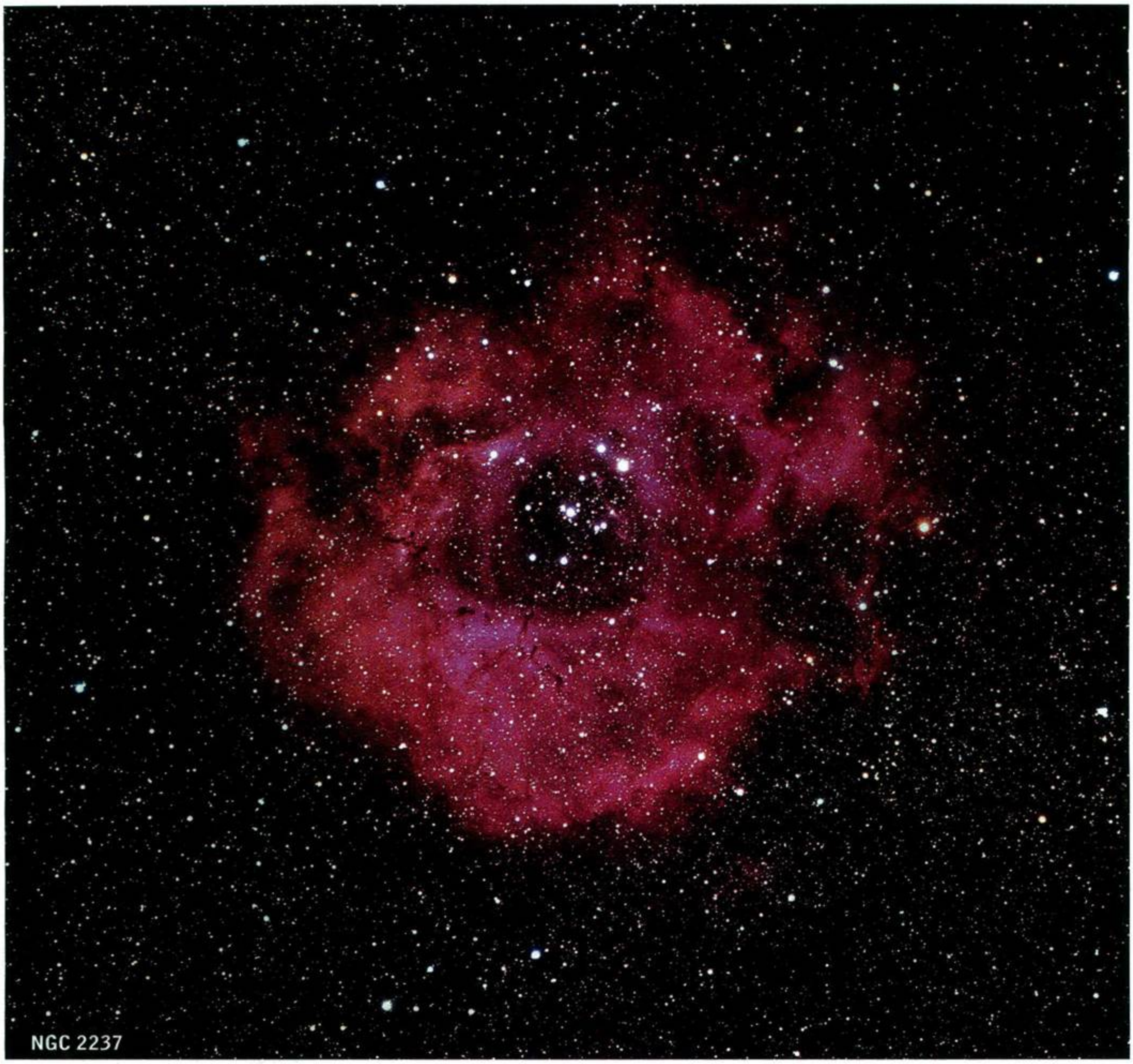
We begin our telescopic tour in far northern Monoceros with the Christmas Tree Cluster, **NGC 2264**. In a small telescope at 50x, a dozen or so stars extend to the east and west of 5th-magnitude 15 Monocerotis. This line forms the half-degree-long base of the tree, whose top points to the south. The southern stars of this asterism do not belong to the cluster, which lies 2,500 light-years from Earth. Larger scopes will show a bright strip of nebulosity 5' long radiating westward from the brightest star. This is but one enhancement of the giant emission nebula Sharpless 2-273, which goes on for 2° to the west. At the top of the Christmas Tree lies the Cone Nebula, an obscuring cloud of dust visible only in the biggest backyard telescopes.

Scan 1° south-southwest of the Christmas Tree Cluster and you'll find the fascinating reflection nebula, **NGC 2261**. Also known as Hubble's Variable Nebula, this object varies in brightness and structure over periods measured in days. At a distance of 2,200 light-years, such rapid changes would suggest that these features move at speeds greater than that of light. Astronomers explain this phenomenon as an illusion created by shadows cast by dark material lying close to the illuminating star, R Monocerotis. NGC 2261 looks like no other object through a telescope. In a 10-inch scope, a bright wedge 2' on a side radiates to the north of R Mon. The cometary form appears uniformly bright with a sharply defined edge. In a 20-inch, internal striations can be seen. With this aperture, I have seen changes in structure from one week to the next.

The open cluster **NGC 2236** lies 3° to the southwest of Hubble's Variable Nebula. Seen from a distance of 10,000 light-years, its 25 stars glow mainly at 13th magnitude. An 8-inch scope at a dark site resolves the cluster into a clump spanning about 4'. Look for a chain of eight stars arranged in an arc on the cluster's northwestern edge.

Our next object shows up with unaided vision on clear, dark nights. Look for the open cluster **NGC 2244** some 2° south of our previous target. It contains 100 stars, a half dozen of which are 8th magnitude or brighter and resolved in a 9x60mm finderscope. The cluster measures 20' across and shows up without optical aid as an enhancement of the Milky Way's band.

Artwork at left by *Astronomy*: Terri Field


NGC 2237

George Greaney

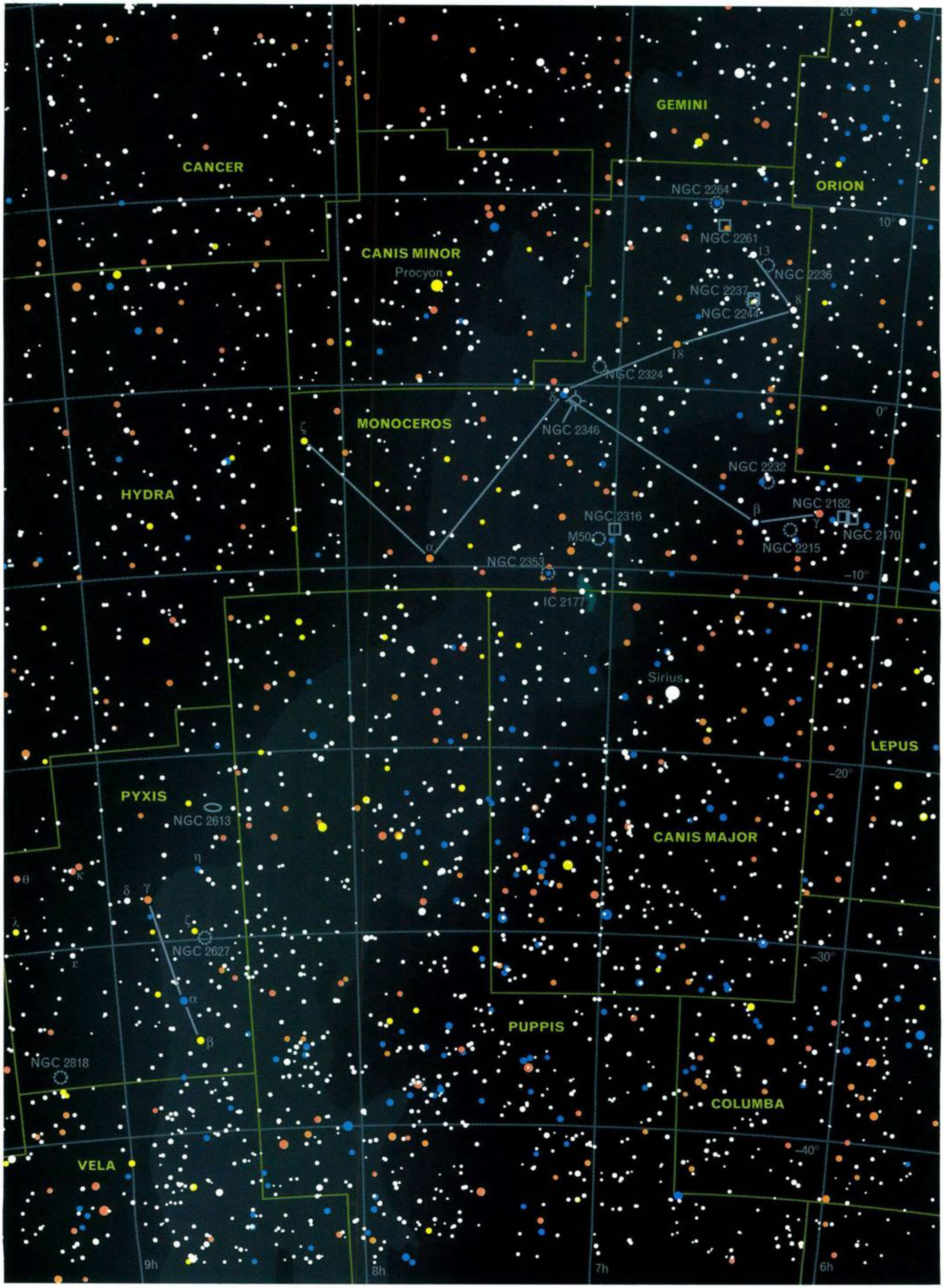
In a 6-inch telescope at 50x, 20 bright stars appear in an oval that's elongated northwest to southeast. Countless fainter stars surround these members, though they are impossible to separate from the rich Milky Way fields. NGC 2244 lies 4,500 light-years from Earth and formed about 2 million years ago.

The best known target in Monoceros surrounds NGC 2244. **The Rosette Nebula** (NGC 2237) appears strikingly different in the eyepiece than it does on photos, where the globules and "elephant trunks" make it so photogenic. Using a nebula filter and a power of 75x shows the entire 1° ring. On the brighter, western side, the inner wall of the ring appears straight with some scalloped detail while the outer wall remains diffuse with an extension to the northwest. The eastern side looks diffuse and much wider. Another straight wall of nebulosity, some 10' long, highlights the northern edge. The entire nebula is set off spectacularly by the associated stars of NGC 2244.

Pan 2.5° northwest of Delta (δ) Monocerotis to find the open cluster **NGC 2324**. This attractive grouping contains 50 stars of mostly 12th and 13th magnitude packed into an oval area 7' by 5' across. Although it's situated against a starry field, the cluster appears nicely detached and shows a distinct edge. Use a magnification of at least 100x for the best view.

Now return to Delta Monocerotis and scan less than 1° west-southwest, where the bright planetary nebula **NGC 2346** will come into view. A halo measuring 45" across surrounds an 11th-magnitude central star. The halo has a diffuse edge and appears slightly elongated east-west, though a 10-inch scope shows no internal structure. As often happens in planetaries with bright central stars, the prominent star is actually a binary companion of the star that ionizes the nebula.

Next head to the southwestern corner of Monoceros, where a group of reflection nebulae resides. These belong to a molecular cloud cataloged as Monoceros R2 that lies 3,000 light-years away. An 8-inch scope shows **NGC 2170** — the brightest of these reflection nebulae — as a bright

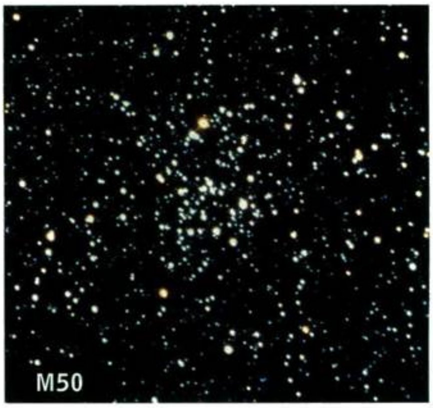

20°
GEMINI
CANCER
NGC 2264
ORION
NGC 2261
10°
CANIS MINOR
Procyon
13
NGC 2236
NGC 2237
8
NGC 2244
18
NGC 2324
δ
NGC 2346
MONOCEROS
ζ
0°
HYDRA
NGC 2232
β
NGC 2182
γ
NGC 2316
NGC 2170
M50
NGC 2215
α
NGC 2353
–10°
IC 2177
Sirius
LEPUS
–20°
PYXIS
NGC 2613
CANIS MAJOR
η
θ
κ
δ
γ
λ
ζ
NGC 2627
ε
–30°
α
PUPPIS
β
NGC 2818
COLUMBA
–40°
VELA
9h
8h
7h
6h

circular haze some 2' across that surrounds a 7th-magnitude star. Continue half a degree east and you'll find another reflection nebula, **NGC 2182**. This one appears fainter, measures 1' across, and surrounds an 8th-magnitude star.

The well-defined star cluster **NGC 2215** lies in the same neck of the woods. It contains 40 stars between magnitudes 11 and 13 across a 6' diameter. Although it shows no central concentration, the cluster stands out well as a compact enhancement of the Milky Way.

Next head 3° northeast to the naked-eye cluster **NGC 2232**. Here several 7th-magnitude stars join with 5th-magnitude 10 Monocerotis, a blue-white gem near the center. A 6-inch telescope at 100x shows the cluster as a group of a dozen stars between 7th and 10th magnitude spanning an area 15' by 10' elongated north-south. At a distance of just over 1,000 light-years, NGC 2232 ranks in 11th place on the list of closest open clusters.

Jason Ware



Lee C. Coombs

Charles Messier's only entry in Monoceros lies in the south-central part of the constellation. One look at **M50** (NGC 2323) through an 8x50mm finderscope reveals how Messier could easily detect this cluster. It even shows up to the naked eye on the best nights, quite an accomplishment for being 3,000 light-years away. In a small telescope at 100x, 50 stars appear within a 12'-diameter circle. The brightest star glows at 8th magnitude, and many more 8th- to 10th-magnitude stars form curving chains through the cluster. A 12-inch scope brings out 75 stars in the area, the most prominent a yellow sun located on the cluster's southern edge.

The comet-shaped emission/reflection nebula **NGC 2316** lies 1° to the west-northwest of M50. A young, hot, 13th-magnitude star illuminates the nebula. In a 10-inch scope at 200x, it measures 40" by 20" and appears uniformly bright. A 14th-magnitude

Deep-Sky Objects in Monoceros and Pyxis

Object	R. A. (2000.0)	Dec.	Mag.	Size	Type	Notes
NGC 2170	6h07.5m	–6°24'	—	2' by 2'	BN	
NGC 2182	6h09.5m	–6°20'	—	2.5' by 2.5'	BN	
NGC 2215	6h21.0m	–7°17'	8.4	10'	OC	
NGC 2232	6h26.6m	–4°45'	3.9	29'	OC	
NGC 2236	6h29.7m	6°50'	8.5	6'	OC	
NGC 2237	6h32.3m	5°03'	—	80' by 60'	BN	Rosette Nebula
NGC 2244	6h32.4m	4°52'	4.8	23'	OC	
NGC 2261	6h39.2m	8°44'	—	3.5' by 1.5'	BN	Hubble's Variable Nebula
NGC 2264	6h41.1m	9°53'	3.9	20'	OC	Christmas Tree Cluster
NGC 2316	6h59.7m	–7°46'	—	4' by 3'	BN	
M50 (NGC 2323)	7h03.2m	–8°20'	5.9	16'	OC	
NGC 2324	7h04.2m	1°03'	8.4	7'	OC	
IC 2177	7h05.3m	–10°38'	—	120' by 40'	BN	Seagull Nebula
NGC 2346	7h09.3m	–0°48'	11.8	55"	PN	
NGC 2353	7h14.6m	–10°18'	7.1	20'	OC	
NGC 2613	8h33.4m	–22°58'	10.5	7.6' by 1.9'	Gal	Sb
NGC 2627	8h37.3m	–29°57'	8.4	11'	OC	
NGC 2818	9h16.0m	–36°37'	8.2	9'	OC	with NGC 2818A

Object: Designation in Messier, NGC, or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size:** Size in arcminutes or arcseconds. **Notes:** Hubble type for galaxies.

star at the nebula's northern edge forms a "Water Jar" asterism with three similarly bright stars to its north.

We have now worked our way to the border with Canis Major, where **IC 2177**, the Seagull Nebula, resides. The Seagull form so apparent in photographs represents just the western arc of a ring 3° in diameter. Sweeping an 8-inch telescope across the field at 40x with an Oxygen III filter, the nebula easily shows as a strip 2° long and 15' wide. The boundary between the eastern edge and the dark sky is particularly complex. Also look for several embedded open clusters, the most prominent being NGC 2335, a compact spray of 25 stars on the nebula's northern end. The entire region of the Seagull Nebula deserves a long sweep both with and without a nebula filter.

A couple degrees east of the Seagull's northern end lies the pretty cluster **NGC 2353**. Some 40 stars of mostly 9th through 11th magnitude scatter across a 10' diameter. A broad band of 11th-magnitude stars appears to run away from the cluster for a half degree to both the northeast and southwest.

It takes a long pan to the south and east to reach our first object in Pyxis. The spiral galaxy **NGC 2613** appears as a bright haze with a slightly brighter center that measures 3' by 1' across when viewed in a 13-inch telescope. NGC 2613 belongs to a major cluster of galaxies 65 million light-years away known as the Puppis Concentration. Although this cluster has a density comparable to that of the Virgo Cluster, the rich Milky Way foreground obliterates most of its members from view.

NGC 2264

James R. Foster

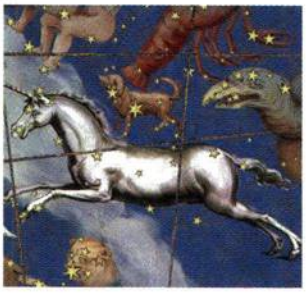
Next head 7° south to the open cluster **NGC 2627**. A scope of moderate aperture brings out 40 stars mostly 12th and 13th magnitude in an area 6' across. A faint background glow hints at the presence of additional stars.

We wrap up our tour with a unique object: an open star cluster containing a proven planetary nebula. **NGC 2818** and its planetary lie in the southeastern corner of Pyxis. The open cluster is a modest arrangement of 30 stars spanning 5'. Most of the visible members glow at 12th or 13th magnitude, and the cluster stands out well thanks to the sparse surrounding field. A chain of ten stars defines the eastern edge of NGC 2818. The planetary nebula appears as a small, moderately bright apple core similar to the Dumbbell Nebula in Vulpecula. An 8-inch telescope shows both lobes, but you need a much larger aperture to bring out the long extensions to the east and west.

Tom Polakis is an aerospace engineer living in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

The Unicorn

"Well, now that we have seen each other," said the Unicorn, "if you'll believe in me, I'll believe in you. Is that a bargain?"
"Yes, if you like," said Alice.
Through the Looking Glass, *Lewis Carroll (1832–1898)*



Few animals have the style or flair — dare we say panache? — of the unicorn. Of course it's easy to attribute astonishing capabilities to a species when completely unencumbered by reality, but that takes little away from the magic of this incredible beast. It almost makes you want to believe that they really do exist.

It also makes you wonder how the unicorn got linked to such an inconspicuous part of the sky. Monoceros earns none of the plaudits of its mythological namesake. The German astronomer Jacob Bartsch, an assistant to Johannes Kepler, invented the constellation in 1624.

But descriptions of the unicorn itself go back thousands of years. The 1st-century Roman naturalist Pliny the Elder depicted it as a ferocious beast having the body of a horse, the head of a deer, the feet of an elephant, the tail of a wild boar, and a single black horn, two cubits long, standing out of its forehead.

The unicorn's horn had its own magic, rendering poison harmless and serving as a storehouse of the animal's strength. Legend says that when being pursued, the unicorn would throw itself off the highest rocks and land on its horn, which absorbed the impact and allowed it to escape. The unicorn would have been nearly invincible if not for its great love of purity. Hunters would take to the fields with a young virgin in tow. The unicorn would approach, lay down next to her, and fall asleep. The deceptive maiden would then signal the hunters, who moved in to capture the innocent beast. — *Richard Talcott*

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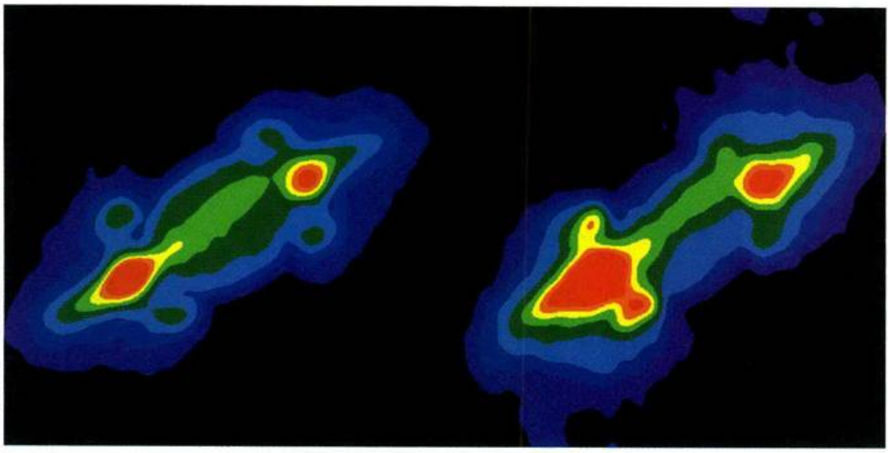


NRAO/VLA/Imke de Pater

Jupiter's radio signature before (left) and after (right) fragments of Comet Shoemaker-Levy 9 collided with the gas giant in 1994.

Is it possible to set up a simple radio telescope system at home? What equipment would I need? What results can I expect? *— Micheal Cleveland, Long Beach, California*

With a modest investment of time and money, simple backyard radio equipment can yield unlimited access to a portion of the electromagnetic spectrum left unexplored by most amateur astronomers.

Radio technology allows astronomers to peer beyond light from stars and galaxies to spot the effects of gas and electrons spiraling around magnetic fields. Measuring the 21-cm emission line of atomic hydrogen to discover the structure of the Milky Way Galaxy and detecting the radio signature of Jupiter are just the tip of the iceberg. With your own radio setup, you'll also get an added appreciation of the underlying science of what you are observing, as radio astronomy consists of much more than just pretty pictures. For example, measuring the 21-cm line of hydrogen allows you to calculate the rotation speed of the Milky Way and to determine its mass. In the process, you'll discover that the galaxy rotates faster than it should at large distances from the center, which gives us our best evidence for dark matter.

If you're interested in learning more about getting started with radio astronomy, check out *Radio Astronomy Projects* by William P. Lonc and *The Radio Astronomy Teacher's Notebook* by Jim Sky. You can obtain both of these publications from Radio-Sky Publishing (www.radiosky.com). And if you'd like to maintain your own radio observatory, the Haystack Observatory (www.haystack.mit.edu) at MIT has designed a Small Radio Telescope (SRT) kit and educational projects. The kit contains a two-axis, computer-controlled mount, a 7.5-foot dish (with a 10-foot upgrade option) and a radio spectrometer for observing the 21-cm line of hydrogen. The kit is available commercially for $4,500, and more information can be found at www.cassicorp.com. — *Michael Cobb, founder of Custom Astronomical Support Services, Inc.*

How were the first stars created? *— David W. Bulloch, Los Angeles, California*

Quite simply, the first stars must have formed in very much the same way that we see stars forming today, such as in the constellation Orion. But the most frustrating thing is that we don't yet understand the details of the star-formation process.

The general points are, however, clear. Basically, a star (and its planetary system) form when a cloud of gas cools enough so that its own heat can no longer hold itself up against its own weight. The cloud's heat is initially wrapped up in the random speed of the atoms and molecules. As atoms collide, they transfer that heat into internal energy of the atom/molecule, which can then be converted into infrared radiation that's eventually lost from the cloud. The net effect is to slow the motions of the atoms, cool the cloud, reduce the internal pressure, and to allow the cloud to shrink a little. More collisions, more conversion of speed to radiation, more colliding, and more shrinking ensue until everything piles up at the center. At least that's what we see happening today.

But the challenges faced by the first generation of stars were likely greater than those of stars forming now. Today, many complex molecules can radiate away the heat of a cloud. (Complex molecules are produced by hot stars and scattered by supernovae and subsequent generations of stars.) The first stars must have formed from a mixture of pure hydrogen and helium. In this case, the only molecule that can be

On the verge of birth, dark dust and molecular gas in Barnard 68 will soon glow with the fire of star formation.

ESO/VLT/FORS Team

readily created is molecular hydrogen, which has a much harder time forming than effective coolants like water, carbon monoxide, and atomic carbon. So star formation was likely a lot less efficient long ago than it is today. — *Gerry Gilmore, Professor of Experimental Philosophy, Institute of Astronomy, Cambridge University*

How do astronomers classify supernovae? What's a Type Ia supernova? — *John Denkmon, Bryan, Ohio*

Astronomers continue to uphold a long tradition of twice classifying supernovae: once based on theoretical considerations and again on observational evidence.

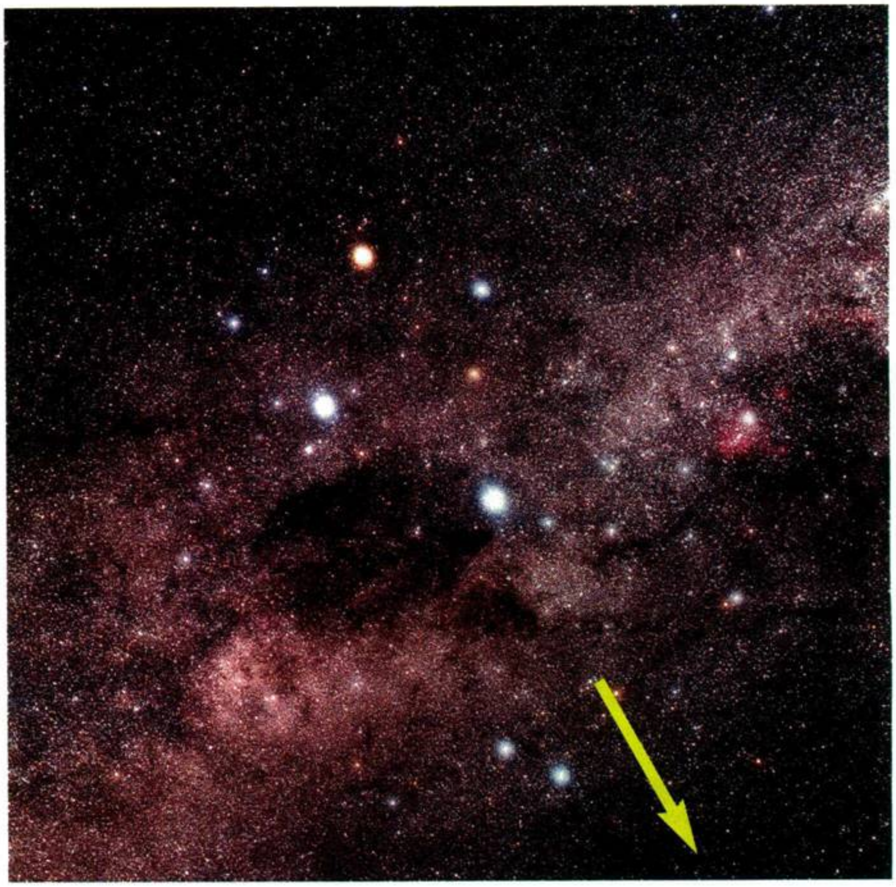
The theoretical division between supernovae is based on triggering mechanism — explosive thermonuclear runaway or collapse of a massive stellar core. Core collapse occurs when a massive star has consumed its fuel (via nuclear fusion) to the point that only iron ash remains. Because iron is incapable of generating energy through nuclear fusion, gravity wins and the core collapses and implodes, leaving behind a black hole or a neutron star. Meanwhile, the outer layers of the star are explosively ejected into surrounding interstellar space.

On the other hand, thermonuclear runaway occurs when a white dwarf robs too much mass from a main-sequence binary companion. Nature places a strict limit on how much mass can be packed into a degenerate white dwarf — about 1.4 times the mass of the sun. Any more than that, and the material making up the white dwarf will undergo runaway fusion, quickly obliterating itself with a release of nuclear energy.

Astronomers also classify supernovae based upon the observed presence of hydrogen gas. By definition, Type I supernovae lack evidence for ejected hydrogen, while Type II supernovae consistently scatter this primordial junk. What's more, astronomers have further subdivided Type I and Type II supernovae (Ia, Ib, Ic, II–P, II–L, II–n, and IIb) based on the presence (or lack) of heavier elements, such as silicon and calcium.

At present there is no direct link between the two modes of classification. That is, both Type I and Type II supernovae may result from core collapse and/or thermonuclear runaway.

Since 1998, Type Ia supernovae have become a popular astronomical distance indicator, as it's generally believed that their peak brightness and subsequent dimming are consistent and predictable. Type Ia supernovae are also unique for the presence of silicon in their spectra. And although astronomers still aren't absolutely sure how Type Ia supernovae are generated, they suspect white dwarfs are the culprit, either from the merger of two white dwarfs or one that has accreted matter beyond the limit of stability for thermonuclear runaway. — *William Schomaker, associate editor*



Luke Dodd

If you can spy the Southern Cross, let it point you in the direction of the South Celestial Pole.

The Northern Hemisphere has Polaris. But what is the nearest star to the South Celestial Pole? — *David E. Francis, Litchfield, Michigan*

Thanks to the slow 25,780-year precessional creep, as Earth's axis of rotation swings around in a vast circle with a 47° diameter, some star will always be closest to both spots of the sky where our planet's axis happens to be pointing. As you know, Polaris now occupies the northern spot, and will continue to crawl closer to the exact motionless point in the heavens for another century, after which it will slowly slip away.

As for the southern pole, the dim star Sigma Octantis is currently the nearest naked-eye star. Sitting in the truly dark and abysmally vacant constellation Octans the Octant, the star fails to grab attention. Your best bet is to extend the Southern Cross downward by five times its length to find it.

Alternatively, you can zoom in on Sigma Octantis by looking for the blankest region of the southern sky. — *Bob Berman,* Astronomy *columnist and author of several astronomy books, including* Cosmic Adventure: Other Secrets Beyond the Night Sky *(Quill).* ■

CONTACT INFO

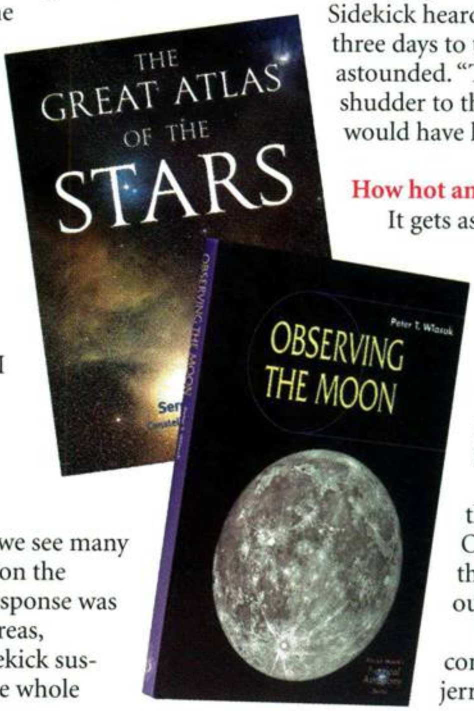
Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live.

Beginner's sky

Diary of a neophyte astronomer. By Jerry Burstein

Amateur astronomy and young minds fit together perfectly: Most kids have the ability to blurt out multiple questions without taking a breath between them, and astronomy inherently lends itself to a barrage of questions.

For two months now, my daughter (a second-grader) and I have braved the cold and spent every clear night stargazing with and without binoculars. Our focus has been primarily on the moon. It's an awesome feeling to hear her ask questions faster than black holes devour hydrogen gas. I have few answers, but by consulting only a small portion of resources available, she and I have come across a lot of good explanations, such as:



Why does it look like the moon has a "face"?

By using our binoculars, we see many bright white and dark spots on the moon's surface. My initial response was "Those are craters and flat areas, honey." Immediately my sidekick suspected I wasn't giving her the whole story, so we turned to the resource material. The bright areas are highlands, containing a heavily cratered record of the moon's violent early history. The dark areas are flooded plains that filled with oozing lava more than three billion years ago.

Galileo first saw these through his homemade telescope and thought they were seas of water. He named them after the Latin word for seas: maria. When viewed together, these maria give the appearance of eyes, nose, and mouth. Early astronomers gave them names. We found Mare Crisium, the Sea of Crises (the "eye" on the right as you view the moon), which is covered with numerous wrinkle ridges visible through binoculars.

Over the course of several different evenings we were able to identify Mare Serenitatis (Sea of Serenity) and the famous Mare Tranquillitatis (Sea of Tranquillity). After my daughter heard that this is where the astronauts first landed, she was even more eager to study the moon. We started looking for individual craters and successfully spotted three prominent ones: Plato, Tycho, and Copernicus.

How far away is the moon and how long did it take the astronauts to get there?

Again, the resources helped out, but I also threw in my own explanation when I answered, "About 240,000 miles (384,400 km) away — or like 50 round-trips from New York to California." When Sidekick heard that it only took the astronauts three days to travel this distance she was really astounded. "That's fast!" she exclaimed. (Still, I shudder to think about how many times I would have heard, "Are we there yet?")

How hot and cold is it on the moon?

It gets as hot as 265° F (130° C) and as cold as –275° F (–170° C).

How big is the moon?

I looked it up and explained that it would take four moons to equal the size of Earth. That made sense to her without further discussion.

We're both excited now when the forecast calls for a clear night. Observing is more fun and easier than I thought. So get outside and start looking around.

Don't forget to send your comments and suggestions to jerry@astronomy.com.

The Great Atlas of the Stars

Serge Brunier; illustrated by Akira Fujii, 112 pages, Firefly Books, Buffalo, New York, 2001; ISBN 1-55209-610-6; softcover, $49.95.

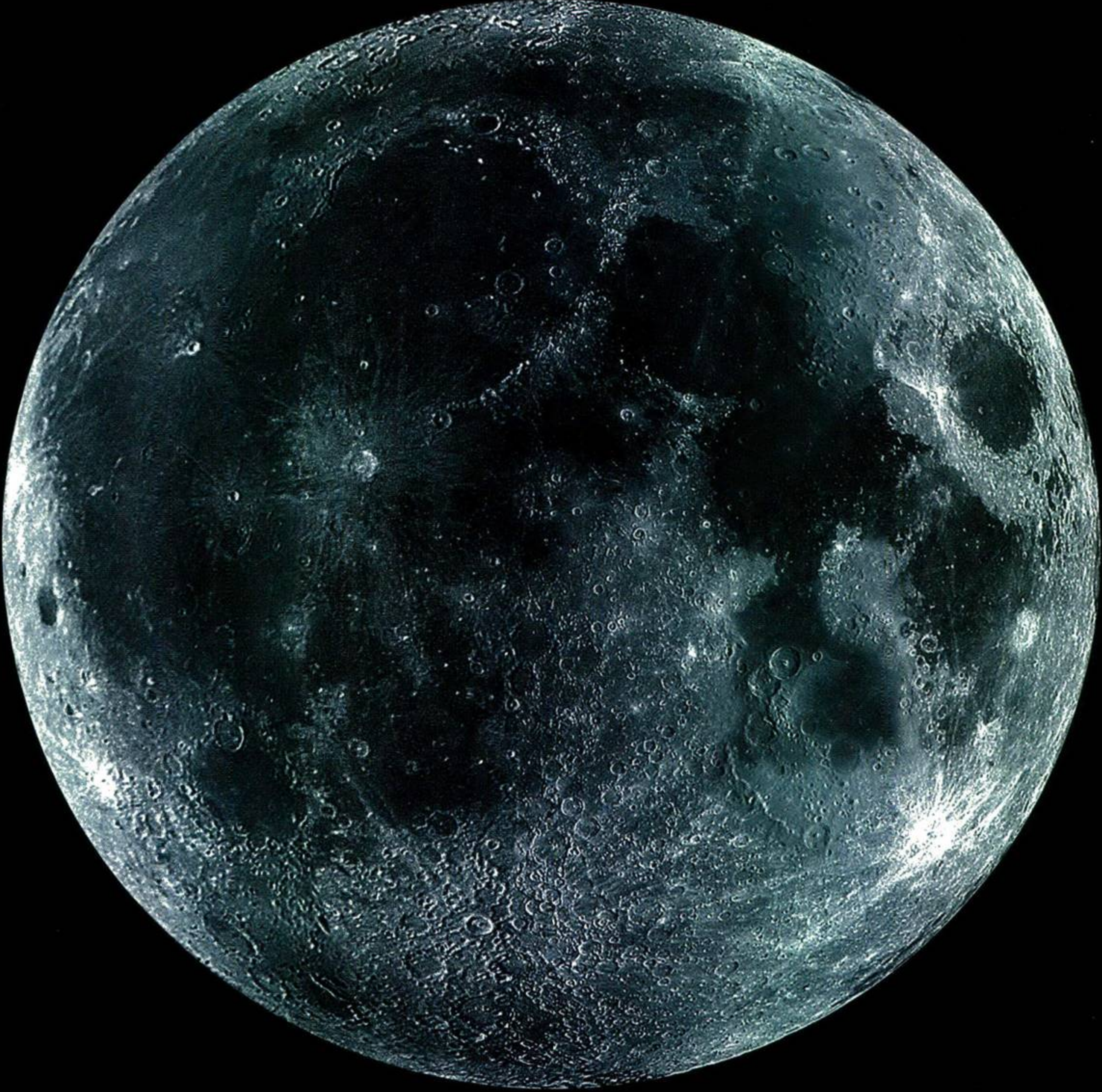
This compelling atlas features 30 full-page (11" by 14") constellation photos, each with a transparent overlay depicting exactly where to find various stars. The test gives history, viewing requirements (naked eye, binoculars, or telescope), and other important facts and details.

Observing the Moon

Peter T. Wlasuk, 256 pages, Springer-Verlag, New York, 2000; ISBN 1-85233-193-3; hardcover, $39.95.

In *Observing the Moon*, author Peter Wlasuk makes all things lunar interesting for every experience level. The book includes material on lunar geology, lunar observing forms, astrophotography tips, a glossary, and a CD-ROM. Amateur observers contributed many of the illustrations for this well-researched book.

Target moon



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H. J. P. Arnold

Astronomy 101

Collectible full page photos will appear in every issue. They are meant to be saved.

Beginner's moon

1 Lunar shadows exhibit sharply defined edges, thanks to the moon's lack of an atmosphere.

2 The moon's stark contrast allows resolution of small features and fine details.

3 Lunar albedo (reflectivity) is only about seven percent — equivalent to that of fresh asphalt.

4 Sunlight sweeping across the moon causes high-relief viewing through binoculars or telescope.

5 Look for the best viewing within 15° of the lunar terminator — the demarcation line between night and day on the moon.

6 Molten lunar lava flowed with the consistency of thin motor oil, as opposed to high-viscosity Earth lava.

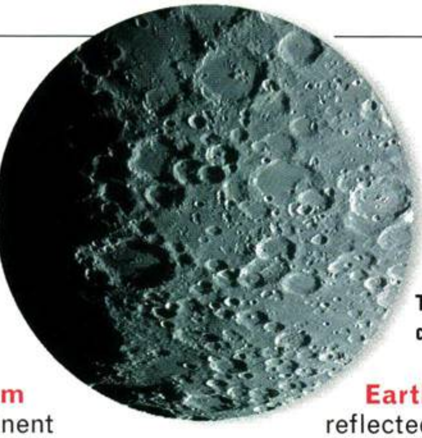
7 Pelted relentlessly by tiny meteoroids in the early history of the solar system, the lunar surface exhibits a battered and dusty appearance.

8 The moon is essentially dead; seismic activity reaches a maximum value of about 2.0 on the Richter scale.

9 Not one fresh crater or other new formation has appeared on the moon in more than 350 years of documented lunar observing.

10 Lunar ray systems composed of rock dust mark the splash patterns of material thrown out by large impacts.

Glossary



The southern end of the moon shows craters in sharp relief. H. J. P. Arnold

Asterism A prominent pattern of stars not considered a complete constellation, such as the Big Dipper or the Pleiades.

Asteroids Small (diameter <620 miles; <1000 km) rocky objects in the solar system, also called minor planets.

Binary star A pair of stars in tight orbit; often mistaken as one star.

Black hole A region of space with such strong gravity that not even light escapes.

Earthshine Sunlight reflected by Earth that illuminates the otherwise dark part of a crescent moon.

Epoch A time period for noting precise celestial coordinates for objects. Current star charts and catalogs are for epoch 2000.0.

Galaxy A collection of stars, gas, and dust held together by mutual gravitational attraction.

Meteoroid A piece of rock or dust in space, which becomes a meteor when it vaporizes in Earth's atmosphere and a meteorite when it strikes Earth's surface.

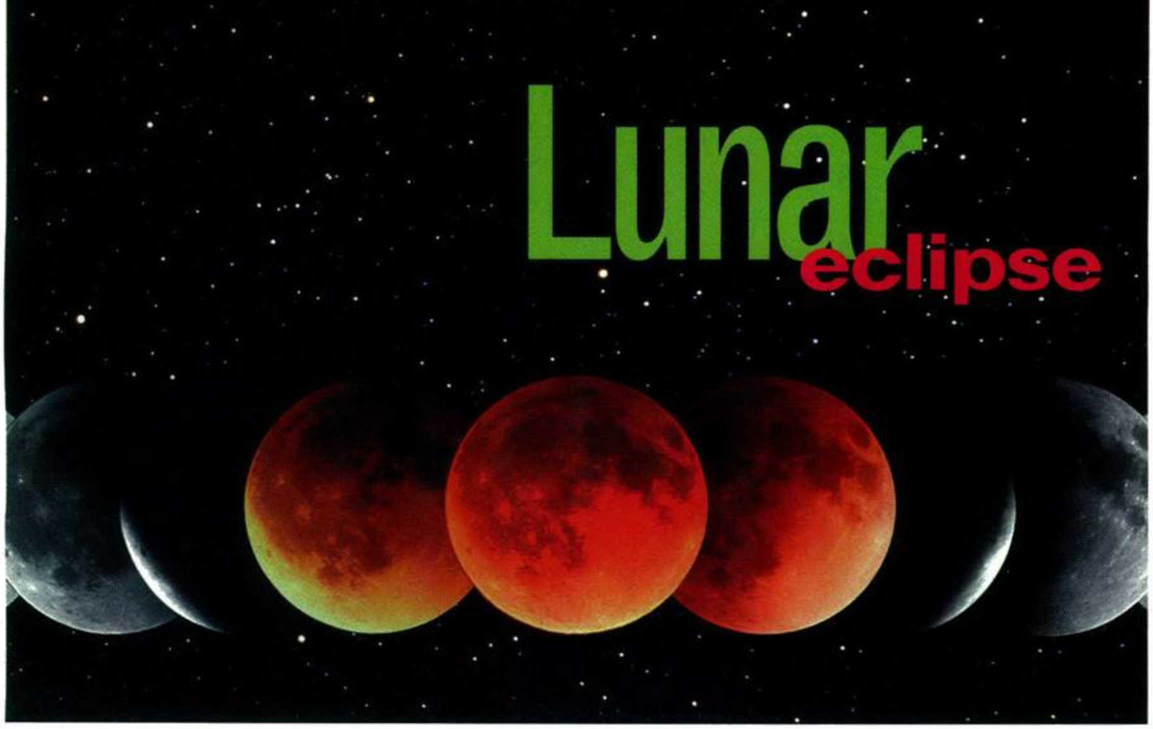
Occultation The passage of one astronomical object directly in front of another.

Opposition The position of a planet when it is directly opposite the sun in the sky.

Variable star A star whose brightness varies.

While you may find some new terms among these entries, many of them appear in articles throughout this issue.

Lunar eclipse



H. J. P. Arnold

The lunar eclipse of April 4, 1996 is set in the Virgo constellation in this composite.

Binoculars perfect for looking at the moon's "watery" past.

By Paul Morledge

We live on a watery planet. Therefore, it should come as no surprise that ancient peoples thought our celestial companion — the moon — was also a wet world. In fact, throughout time many thought of the large dark areas on the lunar surface as oceans.

One thing that fueled this misconception was the observation that the dark patches seemed interconnected, just as the oceans are here on Earth — a similarity that was not lost on those who named these lunar regions. They were referred to as a series of maria or "dark seas." Hence, the names Mare Tranquillitatas and Oceanus Procellarum (the Ocean of Storms), and the Mare Frigoris (the Sea of Cold) near the moon's north polar region.

Just as oceans are but the last stop in a long chain of tributaries for liquid water on Earth, this fact was also reflected in the naming convention of other suspiciously dark landscape features on the moon. Some of the smaller dark areas were dubbed sinus (bays), lacus (lakes), and palus (marsh). Consequently, we see names like Sinus Successus (Bay of Success), Lacus Timoris (Lake of Fear), and Palus Somni (Marsh of Sleep).

Scientists now know that most of these dark, basin-like features on the moon formed from ancient lava flows that solidified in what are currently referred to as mare basalt. Brighter regions that outline the moon's "watery" features are mostly ancient impact craters, peaks, ridges, and small mountain ranges. Many of the craters have their own central mountain, which can be easily resolved with binoculars at full moon.

Binoculars are also ideal to explore the many ancient "seas," "lakes," and "marshes" on the surface of our lunar companion. Be aware that you'll need to limit jiggling to resolve such lunar features. Support your binoculars on a stationary object such as a tripod, fence, or wall, or at least rest your elbows on something like a picnic table, tree, or even a car roof.

So next time you find a clear night sky and a bright moon, just grab a lunar atlas and a flashlight, head outside, and say "Ships Ahoy!" as you sail the lunar seas.

Phil's Binocular Tips:

Beginning astronomers should start with low-power binoculars, such as 7x35 or 7x50. (The first number refers to the power — or magnification — and the second is the diameter in millimeters of the lens pointing toward the sky.) Practice aiming them during daylight before you take them out at night to observe. Learn to adjust the eyepiece width and focus knobs. Zero in on your target, then lift the binoculars to your eyes without shifting your gaze. Support the binoculars on a table or fence post for steadiness. Finally, fine-focus the binoculars for the sharpest view.

— Phil Harrington

Galaxy Hunting in the Big Dog

by David Higgins

The constellation Canis Major is well known for a number of reasons, primarily for holding the brightest star in the heavens, Sirius the Dog Star. With a magnitude of –1.46, Sirius outshines everything in the night sky. Its famous companion, Sirius B, is one of those legendary test objects that seems to beckon observers. The constellation also holds many bright star clusters. But the challenge with Canis Major comes not with stars but with galaxies. Many of its faint galaxies can be glimpsed in an 8-inch scope, but to see them well you'll need a 12-inch or larger scope. Tracking them down is easy with a relatively detailed star atlas, such as *Sky Atlas 2000.0* by Wil Tirion (Cambridge University Press, 1981) or *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi (Willmann-Bell, 1987–1988).

Scattered across the Big Dog like extragalactic fleas lie a wide range of galaxies. Sirius is a good starting point: About a degree east of the Dog Star you'll find **NGC 2296**, a small elliptical glowing feebly at 13th magnitude. This oval haze has a nucleus that stands out as brighter than the nebulosity that surrounds it. About a degree and a half south of Sirius, you'll find the magnitude 12.2 spiral **NGC 2283**. This small galaxy measures 2.8' by 2.0' and floats within a distinctive triangle of field stars. The galaxy appears mottled with a hint of spiral structure. NGC 2283 has an obscure neighbor about 26' to its northwest; **IC 2171**

My Favorite Objects — Alan Goldstein, Louisville, Kentucky

Alan Goldstein

My interest in astronomy started with Comet Kohoutek (which I never saw) and coincided with the very first issue of *Astronomy*. I've observed a wide variety of astronomical phenomena over the years and in 1976, with a pen pal through *Astronomy*, started the National Deep Sky Observers Society, which still exists. I never get tired of my favorite objects.

The Orion Nebula

Okay, I admit it — this is a "gimme." It's almost everyone else's favorite too. I like it because it shows great detail in almost any scope. Big scopes reveal detail that is almost overwhelming. I've seen it appearing from gray to vivid green to ruddy. The dark nebulae provide a sense of depth — they jump out as a foreground to the bright nebulosity.

The Dumbbell Nebula

This shell from a dying star has been a favorite from before I was interested in stargazing. As a child, I saw a color photo from the 200-inch Hale Telescope. I recall seeing the nebula's central star with a 6-inch scope under dark skies. It can appear impressive even under mediocre skies with a UHC or O III filter. The dimpled sides of the dumbbell flare out, forming an oval that is not to be missed.

Galaxy NGC 55

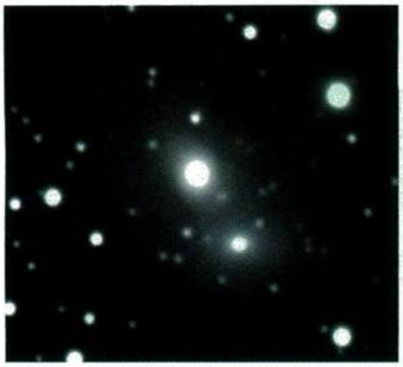
Early on, I developed a fascination with edge-on galaxies. Many have a high surface brightness and are visible from moderately light-polluted skies. While NGC 55 lies pretty far south, it is one of the best when seen in a dark sky. It looks a little like a magellanic barred spiral — not exactly the graceful objects NGC 1365 or NGC 1300, but large and with some detail. The end of the arm closest to us forms a bright star cloud. It reminds me of a galaxy with two separate hubs.

Open Cluster NGC 2169

This would not rate near the top of anyone's favorites list, but years ago I was observing it with a scope that happened to show a distinct arrangement of stars forming the pattern "37." (Some scopes show it backwards.) Once I pointed it out to others, I got lots of fascinating responses. It's a little ironic, as I'm not fond of math.

Globular Cluster M22

I've enjoyed this object since my earliest days of observing. It's a rich cluster that seems to resolve well in a small telescope. The stars seem to fan out from center in a "magical" appearance. The nucleus resolves in an 8-inch scope even though it isn't high in the summer sky. It's easy to find, so showing it to friends is convenient without checking atlases.



Challenging NGC 2292 forms a trio with NGC 2293 and NGC 2295. Al Kelly

Locked in celestial dance, NGC 2207 and IC 2163 are intertwined spirals. Al Kelly

Distant spiral NGC 2280 is visible in moderate sized telescopes. Al Kelly

is a faint spiral that glows at magnitude 14.6. Measuring 1.6' by 0.3', this galaxy requires averted vision on the part of small telescope users and does not reveal much detail even in large backyard telescopes.

About 2½° southwest of the sprawling open cluster Collinder 121, you'll find a neat grouping of three galaxies. **NGC 2293** is the largest and brightest of the group. This oval haze measures 4.3' by 3.0', glows at magnitude 10.7, and has a bright nucleus surrounded by a greenish-white area of nebulosity. No mottling or spiral structure is visible. Just west of NGC 2293, you'll find **NGC 2292**. This glow measures 4.2' by 2.3' and has a magnitude of 10.8. The nucleus is a little brighter than the rest of the galaxy, but not much else is visible. The final galaxy in this group is **NGC 2295**. Located west of NGC 2292, this object is a small, extended haze that measures 2.4' by 0.7' and glows at magnitude 12.7. It's elongated east-west and shows little detail, although its nucleus is somewhat brighter than the rest of the galaxy.

Next, move about 1½° southwest of this group to find two more galaxies. **NGC 2280** is a fairly large, bright Sb-type spiral that measures 6.3' by 2.8' and has a magnitude of 10.5. Elongated roughly east-west, it has a distinct nucleus surrounded by a mottled haze. You'll see some hint of a dust lane and spiral structure. NGC 2280 sits in the middle of a square of field stars, and lies at a distance of about 70 million light-years. **NGC 2272** can be found about 30' northwest of NGC 2280. This small, lenticular galaxy measures 2.6' by 1.8' and has a visual magnitude of 11.7. Its nucleus is a little brighter than the surrounding nebulosity, but not much else is visible. NGC 2280 has a small neighbor located 18' to the northeast. **ESO 490–35** is a magnitude 13.6 galaxy that measures 1.0' by 0.8'. Through small telescopes this faint object requires keen use of averted vision for a satisfying view. Even through large backyard telescopes, the view improves little.

The southern portion of Canis Major, the area that borders the constellation Puppis, has several other galaxies that you can add to your list of targets. About a degree east of Epsilon (ε) Canis Majoris you'll find **NGC 2325**. This 11th-magnitude type E4 elliptical measures 3.2' by 2.2' and has a bright nucleus. It is flanked by two faint field stars and two very challenging neighbors within the same eyepiece field. NGC 2325 lies at a distance of about 80 million light-years. **ESO 427–26** lies about 16' northwest of NGC 2325. This small object radiates at magnitude 13.6 and measures 1.5' by 0.5'. The other neighbor is located close to NGC 2325; **ESO 427–27** lies 3' southwest and is a tough target at magnitude 14.4. Measuring 1.1' by 0.4', this galaxy has a very low surface brightness.

Aiming your scope about midway between Chi (χ) and Lambda (λ) Canis Majoris, you'll find **NGC 2267**. This spiral measures 1.7' by 1.3' and has a magnitude of 13.2. Faint even in a large backyard telescope, this small galaxy suffers from low surface brightness and looks like a faint round glow. Two degrees north of Eta (η) Canis Majoris you'll find **NGC 2380**. This elliptical measures 2.5' by 2.3' and has a visual magnitude of 11.5. Uniform in brightness, the overall surface illumination is rather low considering that this is an 11th-magnitude object.

You'll have to keep hopping to find all the galaxies in the western half of Canis Major. A degree east of the open cluster NGC 2204, you'll find a pair of tightly grouped galaxies. **NGC 2211** is the brighter of the two, with a magnitude of 12.7, and measures 1.4' by 0.6'. This elongated glow has a bright nucleus that is extended east-west, but not much else is visible. Just east of NGC 2211 you'll find its neighbor, **NGC 2212**. This small oval haze measures 1.4' by 0.9' and, at magnitude 13.4, its nucleus is a little brighter than the surrounding light.

South of this uninspiring pair, you'll find a more unusual pair.

Astro Imaging Workshop

Catching the Light: Digitally Enhancing Your Astrophotos

So you've gotten your astrophotos back from the lab and they're lacking that expected "zing"? Fear not! Faint, low-contrast objects need a special boost to look really wonderful, one that can only be provided by digital enhancement. Powerful home computers and image processing software such as Photoshop have opened new worlds to film astrophotographers. It's a several-step process that is much easier than it might at first seem. Once learned, it will unlock the power of your images.

First you need to scan originals, digitizing them into pixels. A typical scan may measure 2,048 by 3,072 pixels; you can scan the images yourself with a desktop scanner such as an HP Photosmart or the images can be scanned onto a Kodak Photo CD at your local camera store.

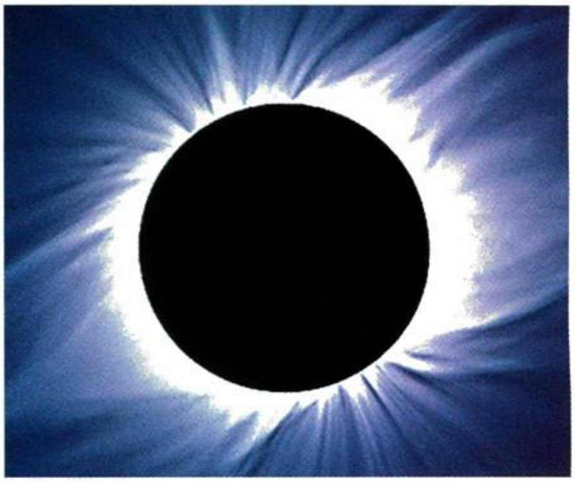
Scan the images at the resolution you intend to use. For photo reproduction, you'll want a high-resolution image of something like 18 megabytes. If you just want to display an image on your computer screen, you may only need a one megabyte image. Put a copy of the scanned image away and work on another in case something goes wrong.

As you work on images, calibrate your monitor to avoid wandering through a digital Twilight Zone. You can do this by creating a step wedge in Photoshop. This will create a strip of grayscale steps that shows gradients between black and white. Next, set a "black point" — that is, the value of the darkest pixels in the image. It shouldn't really be black, but should consist of a deep, dark blue. Aim for an RGB mixture of 15–15–15, or even 15–25–45, which I prefer.

Most of the image adjustment can be done in Photoshop with the "adjust/levels" control, which allows you to manipulate a histogram showing the distribution of the image's pixels. Dragging the triangles to suit your visual taste will improve the contrast, brightness, and overall "snap" of the image, often boosting color considerably too. To work on color specifically, use the program's "adjust/color balance" and "adjust/hue/saturation" controls. You can further enhance some images by applying an unsharp mask filter.

When you've adjusted the image to suit your taste, archive it on disk or CD-ROM and you'll have a variety of means of creating output. Low-resolution versions can be placed on web pages or sent to friends. High-resolution versions can be sent to *Astronomy* for possible publication. The bounds are nearly endless; I invite you to visit my web site, http://www.astropix.com/index.htm, for additional information.

— *Jerry Lodriguss*



Coronal streamers emerge from digitally processed solar eclipse shots like this made in 1998. Andreas Gada and Jerry Lodriguss

Subtle interplay between dark nebulae and bright Milky Way clouds emerges clearly when digitally enhanced. Jerry Lodriguss

Enhancement makes possible blending sky, comet, foreground hills, and people in this composite image. Jerry Lodriguss

NGC 2207 is a magnitude 10.8 elongated haze. Measuring 4.8' by 2.3', the Sc-spiral galaxy has a bright, elongated nucleus extended east-west, with a hint of arms and a mottled appearance. This object lies at a distance of 110 million light-years. What appears as a double nucleus is caused by a companion galaxy, **IC 2163**. This galaxy measures 3.0' by 1.2' and has a magnitude of 11.9. No brightening of the nucleus can be seen. **NGC 2216** lies a degree and a half southeast of NGC 2207. This faint spiral measures 1.4' by 1.2' and glows at magnitude 12.8. At high magnification, you may spot some hint of a spiral arm. Averted vision helps to bring it out, but in scopes smaller than 16 inches it is not visible. A faint field star lies on each end of the galaxy.

Two other galaxies can be found within a degree of NGC 2216. **NGC 2227**, an SBc barred spiral, resides about a degree east of NGC 2216. This small, faint galaxy measures 2.2' by 1.3' and glows dimly at magnitude 12.7. Lying 85 million light-years from Earth, this object has some hint of a brightening in the nucleus. A brighter and easier target exists in **NGC 2223**, an S(B)b type barred spiral. About a degree southeast of NGC 2216, this magnitude 11.8 galaxy measures 3.2' by 2.3'. NGC 2223 has a nucleus a little brighter than the haze that surrounds it. There is some evidence of mottling and a noticeable field star on the southeast edge of the galaxy. It lies at a considerable distance; some 110 million light-years away.

About 2½° due east of Xi (ξ) Canis Majoris, look for **NGC 2271**. This 13th-magnitude elongated haze measures 2.1' by 1.5', with a bright nucleus elongated east-west. About 2° southwest of NGC 2271 you'll find **NGC 2263** at the apex of a triangle formed with NGC 2271 and Xi Canis Majoris. This galaxy is a small, elongated haze that extends northeast-southeast. It measures 2.6' by 1.6' and glows faintly at magnitude 12.9.

Down in the southwestern corner of Canis Major we find our three final galaxies. **NGC 2217** is the brightest. This type SBa, magnitude 10.7 barred spiral measures 4.5' by 4.2' and presents a uniform glow. The nucleus is bright with no discernible detail visible, lying at a distance of about 55 million light-years. About 2° north and west of NGC 2217 lies **NGC 2206**, a barred spiral of type $S(B)b^+$ measuring 2.5' by 1.3' and glowing at magnitude 12.2. It's elongated northwest-southeast and its nucleus is a little brighter than the surrounding haze. **NGC 2206** is an enormously bright object: It lies at a distance of about 260 million light-years. About 3' to the southeast you'll find a companion galaxy. **ESO 489–28** glows faintly at magnitude 14.9 and measures 0.8' by 0.5' with no detail visible. Using averted vision will be a great help with this most challenging object.

We all have a tendency to hibernate during the winter and telescopes tend to stay indoors. If you can resist the call of the roaring fire, however, the Big Dog will provide you with several evenings of fine galaxy observing.

The barred spiral disk of NGC 2217 can be viewed with any backyard scope. Al Kelly

A deeper exposure of NGC 2207 and IC 2163 reveals knots in the arms. Al Kelly

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David Higgins uses his large telescopes to survey the deep sky from outside Oklahoma City.

Challenging Comets/ Feb. 2002

In any month, usually several comets glow brightly enough to become visible to those with large telescopes. Here are coordinates and magnitudes:

C/2000 WM1 (LINEAR)

Feb. 1	19h45.9m, –45°40', 5.5
Feb. 10	19h32.0m, –38°25', 6.3
Feb. 19	19h26.4m, –30°56', 7.1
Feb. 28	19h24.2m, –23°33', 7.8

19P/Borrelly

Feb. 1	12h58.6m, 48°03', 12.8
Feb. 10	12h54.3m, 50°10', 13.2
Feb. 19	12h45.6m, 51°52', 13.6
Feb. 28	12h33.4m, 52°58', 14.0

7P/Pons-Winnecke

Feb. 1	15h37.1m, 5°51', 14.6
Feb. 10	16h01.2m, 5°10', 14.2
Feb. 19	16h26.3m, 4°31', 13.7
Feb. 28	16h52.5m, 3°52', 13.3

C/2000 SV74 (LINEAR)

Feb. 1	23h08.6m, 54°47', 14.0
Feb. 10	23h14.6m, 55°28', 14.0
Feb. 19	23h21.8m, 56°24', 14.0
Feb. 28	23h30.0m, 57°37', 14.0

P/2001 MD7 (LINEAR)

Feb. 1	1h51.1m, –2°08', 14.7
Feb. 10	2h18.9m, 1°32', 15.0
Feb. 19	2h45.5m, 4°53', 15.1
Feb. 28	3h11.1m, 7°51', 15.4

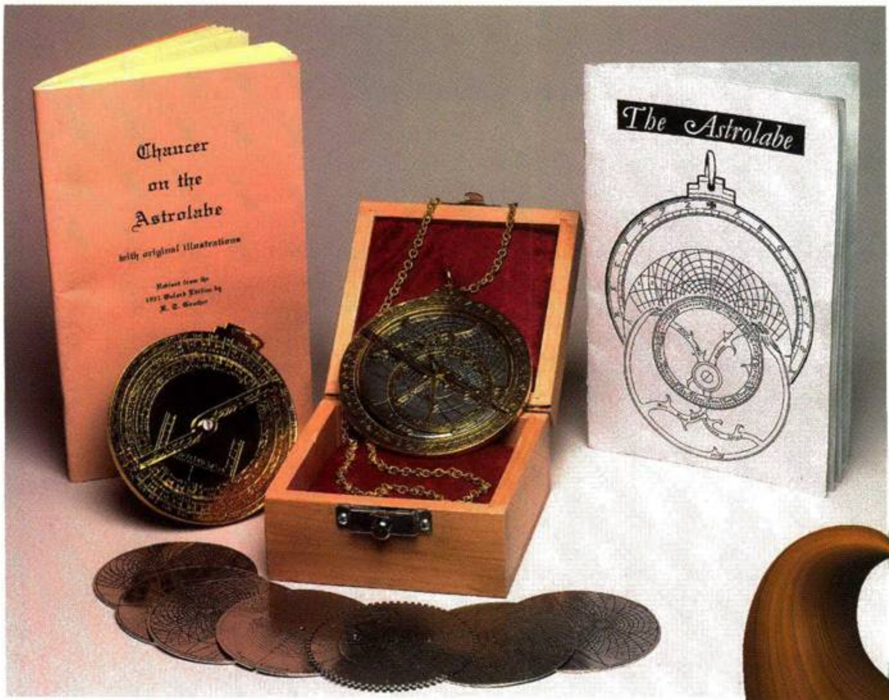
P/2001 Q2 (Petriew)

Feb. 1	10h12.6m, –12°59', 14.7
Feb. 10	10h00.8m, –11°35', 15.0
Feb. 19	9h49.6m, –9°49', 15.2
Feb. 28	9h39.8m, –7°52', 15.5

C/2001 N2 (LINEAR)

Feb. 1	20h24.4m, 13°48', 15.9
Feb. 10	20h27.4m, 13°47', 15.8
Feb. 19	20h30.2m, 13°55', 15.7
Feb. 28	20h32.6m, 14°12', 15.5

PRODUCTS



A Collectible Astrolabe

Astronomical computers aren't anything new — nowadays, they just run on electricity or batteries. Centuries ago, astronomers, surveyors, sailors, and others relied on planispheric astrolabes to take measurements, estimate time, and navigate the heavens as well as the seas.

Use this astrolabe to determine time, predict sunrise and sunset, locate planet placement and altitude, or — in a non-astronomical sense — "fix your position" and measure heights of different structures. You'll find that this ingenious device is really an ancient astronomy "computer" that runs on muscle and brainpower. Granted, it takes little muscle to move around the various components; what really powers an astrolabe is the intelligence behind it.

Now you can figure it out for yourself thanks to this handsome reproduction from Norman Greene's Workshop in Berkeley, California. Each handmade astrolabe comes with eight removable plates in a velvet-lined birch box. The various plates correspond to six different north-hemisphere latitudes, one universal horizon, and one terrestrial horizon.

The astrolabes "mainframe" (if you will) is intricately carved with the proper astronomical markings and accommodates the interchangeable parts with ease. Its 4-inch diameter fits nicely in the palm of your hand. Two booklets are included.

Anyone with an interest in astronomy-related artifacts will appreciate the fine craftsmanship and complexity of this gorgeous collector's piece. Norman Greene also offers a selection of hand-crafted reproductions of armillary spheres, several models of astrolabes and tabletop orreries, and an assortment of sundials.

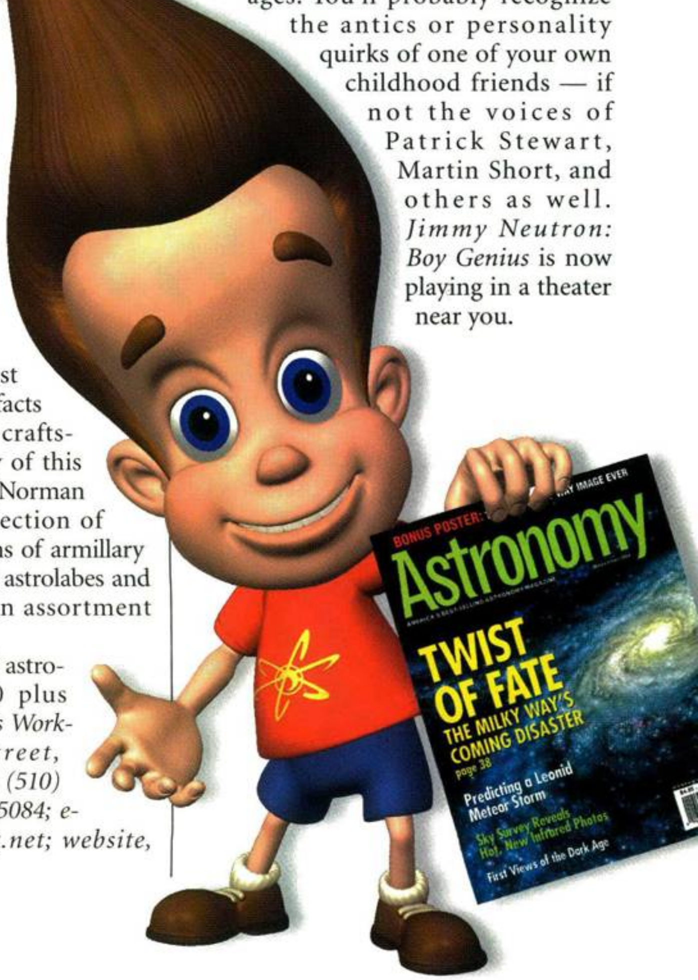
The 4-inch gold-plated astrolabe set sells for $290 plus shipping. Contact *Greene's Workshop, 1215 Fourth Street, Berkeley, California 94710; (510) 524-1109; fax: (510) 524-5084; e-mail, norm@puzzlering.net; website, www.puzzlering.net.*

Paramount Pictures and DNA Productions present

Jimmy Neutron: Boy Genius

Seems the old adage, "Be careful what you wish for — you might just get it," holds true even for cartoon characters. Jimmy Neutron and his friends act like typical kids in good old timeless Retroville (a place where anything that was ever cool exists side-by-side with stuff like home computers and personal rocketships). And like many preteen kids, Jimmy and his friends wish they didn't have to hassle with parents who cramp their style. Yet when Jimmy Neutron realizes that some green, gooey, egg-yoke-type aliens hold his parents captive, he and his peers use their intelligence and imagination to rescue all the adults.

This full-length computer-generated animation of Jimmy Neutron's adventures is sure to captivate viewers of all ages. You'll probably recognize the antics or personality quirks of one of your own childhood friends — if not the voices of Patrick Stewart, Martin Short, and others as well. *Jimmy Neutron: Boy Genius* is now playing in a theater near you.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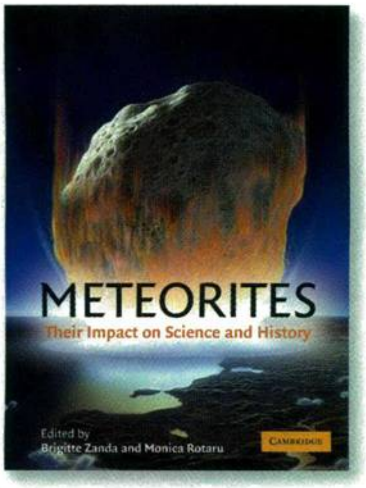

METEORITES
Their Impact on Science and History
Edited by
Brigitte Zanda and Monica Rotaru
CAMBRIDGE

Meteorites: Their Impact on Science and History

Edited by Brigette Zanda and Monica Rotaru, 128 pages, Cambridge University Press, New York, 2001; ISBN 0-521-79940-6, softcover, $18.95.

Aliens lie among us. Few are noticed because most are simply small, dark rocks lurking among the other countless rocks of Earth. About 20,000 fall from space each year. They are found in every region of the planet, and yet they are the rarest and most exotic of rocks. Unimpressive to the naked eye, these ancient, invaluable treasures are physical samples of other "worlds" that we can hold in our hands and examine. Their interiors retain highly detailed records of the formation of planets and the origin of the solar system, and reveal clues regarding the processes, materials, and environments that existed before the sun and planets formed.

These aliens are meteorites, and they come from asteroids, Mars, and the moon. Many contain stardust — solid samples from other stars. Modern analytical techniques enable us to study these samples in exquisite detail to expose the secrets locked within.

Meteorites: Their Impact on Science and History gives a full description of the nature and origin of meteorites and the wonderful records they have preserved for billions of years. The book strives to update the knowledge acquired by the study of meteorites — particularly those in the collection of the French Museum of Natural History. It succeeds admirably with an international dream team of over 20 authors, all experts in various disciplines involved in meteorite study. Represented fields include geology, mineralogy, chemistry, physics, astronomy, paleontology, and the history of science. Experts provide insight into cutting-edge research and theories.

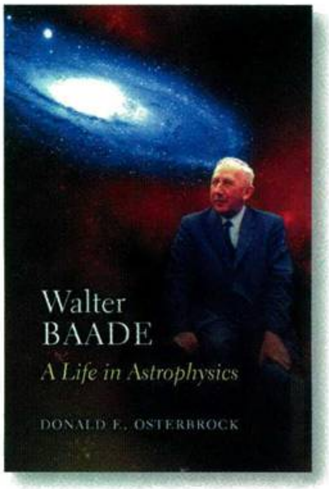
Quite often, the use of multiple authors is not successful in a popular book, but here the styles have been successfully integrated with one another and provide a broad overview of meteorites and their impact on science and history. It is written for the general reader; no prior knowledge of meteorites is needed. The sections often discuss technical details, but not so deeply as to discourage the casual reader. The book touches all of the main areas related to meteorite study.

Meteorites not only describes what these errant rocks can tell us about the early solar system, but also contains fascinating background material on the history of the recognition of the first meteorites and the steps it took for people to finally recognize that stones really do fall from heaven.

The book has a somewhat unconventional topical organization but it is highly recommended reading for anyone interested in meteorites and the early solar system. It is an excellent complement to other popular books on meteorites, such as Richard Norton's *Rocks from Space: Meteorites and Meteorite Hunters* and Hap McSween's *Meteorites and Their Parent Planets.*

A blessing and a curse of the book is that nearly every other page contains a sidebar. This is a curse because if you are intently following an author's description of something, you inevitably run into a sidebar. In most cases this insert is so tempting that you read it immediately and your prior concentration is broken — mostly because the sidebar is not immediately related to the local text. On the other hand, a casual reader or someone going over the book a second time may wish to just skim the sidebars.

In any case, I highly recommend this book on alien rocks and their impact on our understanding of the origin of the solar system and of our place in the universe. — *Donald Brownlee, University of Washington*



Walter Baade: A Life in Astrophysics

Donald E. Osterbrock, 270 pages, Princeton University Press, Princeton, New Jersey, 2001; ISBN 0-691-04936-X; hardcover, $29.95.

The German-American observational astronomer Walter Baade (1893–1960) was a giant of stellar and galactic astrophysics. Astronomical historian Donald Osterbrock's new book is a delightfully engaging account of Baade's life and times, and a welcome addition to the history of 20th-century astronomy.

Osterbrock's research into Baade's life is complete and deeply contextual. The narrative Osterbrock provides is made all the more touching by the fact that he knew Baade well early in his own career, in the 1950s.

Although his name is not as recognizable as other luminaries of the times (like Harlow Shapley and Edwin Hubble), Baade is undisputedly among the most accomplished observational astronomers of the 20th century. Osterbrock, an astronomer and astronomical historian of epic proportions himself, describes how and why Baade's greatest contribution to astrophysics was the discovery of two distinct stellar populations: the metal-rich, younger, less dynamically evolved, and metal-poor, older stars (i.e., the so-called Population I and II stars, respectively). This discovery opened fertile new ground that engaged and illuminated stellar and galactic evolution research for decades.

Baade, popular with his peers for his warm and polite personality, and highly respected for his talents, also contributed to many other aspects of astrophysics.

BOOKS

His work included critical early contributions to the study of supernovae, globular clusters, and a revision of Hubble's distance scale. Readers will enjoy Osterbrock's description of these experiences and adventures.

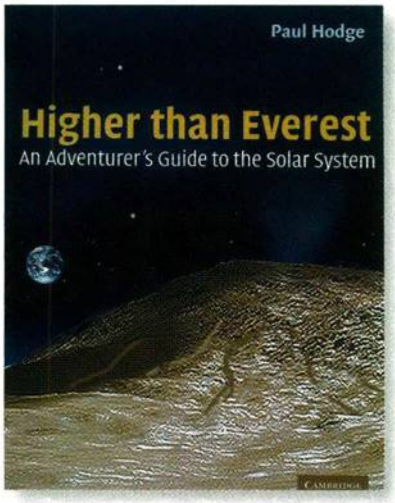
Painstakingly researched, Osterbrock's biography traces Baade's upbringing and education in Germany, his career in America, his relationship to World War II as a German–American, and his late return to his native Germany in the year preceding his death. It is stunningly complete, taking time, for example, to mention Baade's work in planetary science (e.g., studying the lightcurve of minor planet Eros and the brightness of Pluto).

The book is amply illustrated, richly footnoted, and well written. It is not without minor flaws (such as the radial velocity "4.2x104 km/sec," surely meant to be 4.2x10^4 km/sec); but such nuisance errors are easily overlooked, for the narrative comprises a fascinating account of Baade's life, accomplishments, and perhaps most interestingly, his times. Never before the early and mid-20th century did astronomy flourish so fast, and yet from today's Toflerian perspective at the dawn of the 21st century, it seems so quaint and leisurely. Osterbrock's exposition caused me to consider the depth of this cultural divide between Baade's research era and ours.

I read Osterbrock's *Baade* in a single weekend, devouring its rich details about the man and his times, Baade's eagerness to apply the emerging technologies (e.g., photoelectric detectors), and his deep contributions to the now mature fields of stellar evolution and galactic evolution. Osterbrock's book is a wonderful read and pleasing addition to my bookshelf. I recommend it highly for yours. — *S. Alan Stern, Southwest Research Institute, Boulder, Colorado*

Higher than Everest: An Adventurer's Guide to the Solar System

Paul Hodge, 247 pages, Cambridge University Press, New York, 2001; ISBN 0-521-65133-6, hardcover, $27.95.



The late Doug Adams's popular book, *A Hitchhiker's Guide to the Galaxy*, engaged millions of readers with its existential musings and comedic scenarios. Though quite different in theme and scope, *Higher than Everest: An Adventurer's Guide to the Solar System*, could just as easily be titled "A Hiker's Guide to the Solar System." Paul Hodge's latest book reads like an ambitious hiker's diary as it explores some of the geographic highlights of the world's most intriguing national parks — except, of course, Hodge's book covers the extreme landscape features of the planets and their satellites.

Hodge, a world-renowned astronomer, editor of the *Astronomical Journal*, and popular teacher of planetary science at the University of Washington, offers a refreshing and clever take on the often numbing amount of data and imagery collected in the last few decades of planetary exploration. Anyone interested in the extreme and unquestionably bizarre landforms and processes found on Earth will find Hodge's survey of the planets and moons of our solar system an unfettered joy.

Most of *Higher than Everest* is devoted to virtual mountaineering expeditions — including some detailed, daily itineraries and route maps — of the great peaks on Mars (Olympus Mons and Mount Ascraeus), the moon (Mount Blanc and Mons Pico), Venus (the Maxwell mountain range), and Jupiter's moon Io.

Some eye-popping descriptions of what you'd see as you climbed these great mountains of our solar system makes it all the more engaging. For example, here's how Hodge describes the vastness of Mount Olympus's base: "In fact, a climber would spend much of the time climbing the peak without being able to see the summit, which would be beyond the horizon."

But Hodge isn't just concerned with the "higher" realms of our solar system. He takes you on virtual hikes into the deep chasms of Mars (Mariner Valley), the craters (Copernicus), and valleys (Alpine Valley) of the moon. Readers also take a ski trip across Mars's south polar cap, go "snowboarding" through the "icy missiles" of Saturn's ring systems, and then soar on an air-balloon ride above Venus's mysterious volcanic features — most notably the "arachnoids" and "coronae."

While giving readers some background scientific information about how such extreme structures might form, Hodge occasionally lapses into geologic techno-speak, but, in general, this voyage remains accessible to even those with the most modest of science backgrounds. He is particularly adept at comparing many of the featured alien landforms with their closest terrestrial counterparts, and he uses some fantastic images to illustrate his points. — *Paul Morledge, associate editor*

Imagining Space: Achievements, Predictions, Possibilities: 1950–2050

Roger D. Launius and Howard E. McCurdy, 176 pages, Chronicle Books, San Francisco, California, 2001; ISBN 0-8118-3115-9; hardcover, $35.00.

Imagining Space offers a comprehensive history of space exploration from the 1950s through today, with predictions for the next 50 years. Roger Launius, chief historian for NASA, and Howard McCurdy, a space policy professor at American University in Washington, D.C., transport readers into the futuristic world of space travel. Quotations from Carl Sagan, Arthur C. Clarke, and others are scattered throughout. Engaging text sprinkled with over 150 archival photos and illustrations, as well as a farsighted foreword by Ray Bradbury, set up the reader for the potentials of future space exploration.

The first chapter, aptly entitled "Wondrous Visions," introduces the fantastic possibilities imagined early on, including the promise of orbiting space telescopes and colonies on the moon.

(continued on page 96)

The Webweaver Picks

by Richard J. Bartlett

It's 1 A.M. and you've just sighted the latest LINEAR comet. You're bursting with excitement — but your family is fast asleep and your best friend will only tolerate a phone call at this hour if you're one answer away from winning a million dollars. But you've got to tell the world about your discovery. Fortunately, in a very literal sense, now you can, thanks to the following astronomy forums.

Record your observations for posterity in the Amateur Astronomy Observer's Log (AAOL). The site, (http://www.lies.com/aaol/), is a great resource for amateurs who want to record their observations on celestial wonders. You don't need to be an expert to contribute, and your notes may help others with their own observations.

But it's late at night, and as you blearily stare into the computer screen, your mind grows as fuzzy as the dirty snowball you've spent hours observing. Was that really the cometary equivalent of "the next big thing" or a case of a Messier mistaken identity?

Check your hunch by taking a trip down the information superhighway to the global village, where you meet and greet fellow astronomers in one of the many online forums. The Astronomy Discussion Page (http://www.astronomyforum.net/) covers all aspects of amateur and professional astronomy.

Two other sites worth trying are the Absolute Beginner's Astronomy Forum (http://network54.com/Hide/Forum/63770), and the Astronomy Campfire (http://killdevilhill.com/astronomychat/shakespeare1.html). Both these sites are more simplistic than the previous two and not as well designed. Discussions (called "strings") are listed without any topical organization.

Absolute Beginner's
Astronomy Page
MAKE OVER $500 CASH

Perhaps by now you're not only questioning your own observations, but also the quality of your telescope's optics. If so, visit Telescopes.org at http://www.telescopes.org. This name is a bit misleading: the forum is quite expansive and covers all aspects of astronomy, including an area for submitting your latest observations.

@stro pages.com

The @stro Pages (http://theastropages.com) is similarly diverse. This forum for exchanging ideas and observations includes tutorials on astrophotography and telescope building.

After sharing your most intimate cometary thoughts with the world, you're now feeling inspired and want to create your own meeting place for like-minded individuals. You'll be happy to hear it's easy to do. Best of all, it's free.

"Yahoo!" you're thinking, which is exactly right — the Yahoo search engine site dominates the market in providing free chat rooms and forums (called Clubs in Yahoo). But before you start clicking mouse buttons to create your own club at http://dir.clubs.yahoo.com/science/astronomy/, it's worth remembering that beggars can't be choosers, especially when it comes to freebies.

Although you can form a Yahoo Club devoted to almost any subject you like, the format and layout of each club is identical. Each one has pages for messages, photos, chat, news, links, a member's directory, and an event calendar. What makes the different clubs unique is the content and the enthusiasm of its members. In order for your club to be a success, you need to create something that others will want to join. In a very real sense, you'll be designing your own online community. It's up to you to make everyone feel at home.

One website that does just that is the OuterGalactic Astronomy Club (http://clubs.yahoo.com/clubs/outergalacticastronomy). The site is very successful thanks to all its participants, says site founder Michael Schlueter. The OuterGalactic Astronomy club's members range in age from 10-year-olds to professional astronomers; it encompasses every type of observer from around the globe.

Another popular club, All Astronomers Are Welcome (http://clubs.yahoo.com/clubs/allastronomersarewelcome), was founded very recently by two amateurs from different countries: John Kagey in the United States and Cheryl King in the United Kingdom. Kagey instigated the club and called upon King to help. "One of the things that makes our club different is the lack of arguing. And, I make it a point to see that something is posted every day. If no one else posts then I do," Kagey explains.

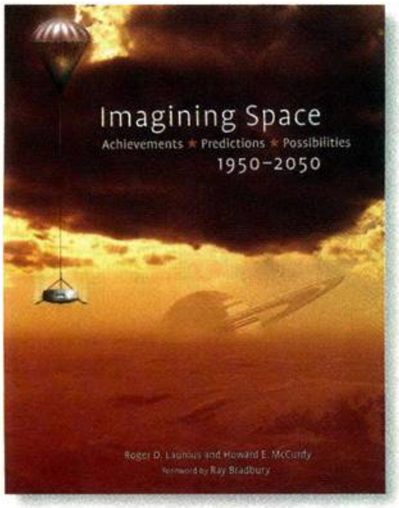
King is no less enthusiastic. "I like the humor and passion we all have for our hobby. Everyone has something valid to contribute. It's a great place to learn something and not feel stupid for asking. My astronomical knowledge is very basic, but I don't feel as if I'm frowned upon because of it," she says.

Perhaps the best aspect of a Yahoo Club is that you're automatically given your own chat room where you can get to know the people you've been swapping observations with for the past few months. While the various chat rooms interact slightly differently, they all share some basic elements: type what you want to say, hit "enter," and it's sent. Everyone else in the "room" reads your remarks and can instantly respond to what you've said — then the "back-and-forth" exchange begins.

The chat rooms that Yahoo provides are better than most because they allow you to send private messages to someone else within the room. Additionally, all of the people present are listed, so you always know who's reading your remarks.

Even for seasoned chatterers, the first time in a new room is usually a bit like your first turn at the karaoke: You're very self-conscious and you're worried about making a fool of yourself. Don't fret. My experiences of chatting with other amateurs online have always been very enjoyable.

So there you have it. Dawn is encroaching upon the eastern horizon and the caffeine is finally wearing off. You've shared your thoughts and feelings with the world and met a few new friends along the way. It's good to know that on those starry nights there's a place you can go where everybody knows your name. — *Visit Richard Bartlett's website, StarLore, at* http://www.starlore.net.


Imagining Space
Achievements ★ Predictions ★ Possibilities
1950–2050
Roger D. Launius and Howard E. McCurdy
Foreword by Ray Bradbury

At a time when interplanetary space flight was still in the realm of science fiction, German rocket scientist Werner Von Braun was laying the groundwork for the U.S. space program. Constrained by the technology of their day, these visions became America's "blueprint for space" — as noted by space historian Fredrick I. Ordway.

Launius and McCurdy cover a variety of topics, ranging from the search for extraterrestrial intelligence, to colonization of the moon and Mars. Concepts run the gambit from visionary, grandiose, and fanciful schemes that may never be realized to more practical and potentially feasible ideas. The authors give an all-embracing view of space flight, covering not only space exploration, but also its commercialization and role in warfare.

For the pop-culture fan, many fine examples of early space flight artwork — which graced popular magazines like *Colliers* and *Popular Mechanics* in the 1950s and 1960s — abound. Other illustrations depict the (sometimes fantastic) proposed future missions. Space-hardware enthusiasts will delight in a full range of futuristic designs, from a cryobot that melts its way through Europa's icy crust to exotic pulse-propulsion interstellar spaceships.

Unfortunately, the authors concentrate on "concept" missions while overlooking upcoming projects such as the twin Mars rovers and the Europa orbiter. It also lacks a chronological listing of all the technical achievements.

If history has taught space visionaries anything, it's that the aspirations predicted here will remain undeveloped for many decades — or will be forever relegated to science fiction. Overall, *Imagining Space* is perfect for when you want to sit back and imagine space. — *Andrew S. Fazekas is a science communicator from Montreal, Quebec, Canada* ■

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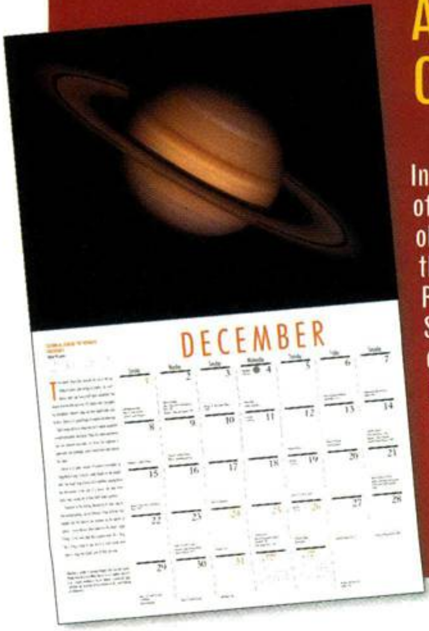

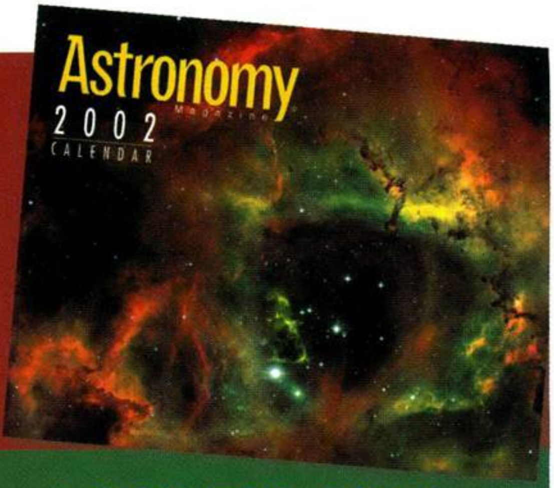

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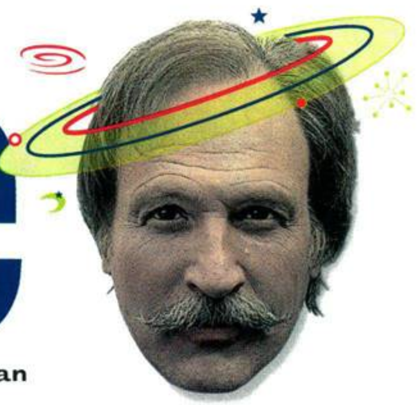

by Bob Berman

The Worst Month of All

There's a masochistic quality to February skywatching.

True, compensatory fun comes from reading about mind-twisting discoveries or seeing the Orion Nebula through a good scope. And the simple soothing infinitude of the Milky Way provides such profound contrast with the 7 P.M. news that there ought to be a law requiring everyone to spend an occasional hour or two under the stars just for our collective mental health.

All that is good. But the flip side of the astronomy coin reveals the well-known Law of Bummers (LOBs). Like gravity, it operates throughout the material universe and explains why even good stars explode, why your neighbor turns on his brightest bedroom light while you're searching for the Crab pulsar, and why total solar eclipses fall over Irkutsk more often than Cleveland.

The Law of Bummers explains why people wear ties around their necks and why school is held indoors in spring. The LOBs' self-perpetuating nature became evident early in life, when, for example, you yearned to take a day off to play in the warm air or hike through the woods. But the only escape from class was a note certifying that you were too sick and miserable to leave the house. The school's position: We'll excuse you from our bummer only if you can prove you have one of your own.

February is astronomy's outstanding bummer month. Not only is it bone-chillingly cold in most of the United States and Canada, but it's also the most overcast month of the year (according to long-term averages). Many parts of the country have mean February cloud percentages of 60 to 70 percent — which tend to linger for days in contrast to summer's more rapid weather changes.

Even when it's clear, there's another much less publicized handicap: skyglow. As we all know, deep space objects require the darkest possible background. In theory, February's cold dry air should oblige, but the hex in this brew is the change in the ground's albedo at this time of year.

Albedo, you'll recall, is the ground's reflectivity. Although Earth's overall albedo is usually listed as 38 (meaning we repel 38% of the sunlight that strikes us) our planet varies its reflectivity more than any other. This month it's easy to see why. Leaves and foliage barely reflect light at all, so their albedo is only 15. Water also has a low albedo at small reflection angles, which is why lakes look dark from space. Asphalt parking lots and city roads have low albedos of 12, and cement sidewalks are not much shinier. Notice that all these light-absorbing groundcover components abound during warmer months.

Winter offers a totally different picture: It gleams. Dark foliage is gone, lakes have turned to shiny ice, and vast regions of the ground are snow-covered. (Snow's average albedo is 75). Streetlights and parking lot illumination, which fortunately nowadays are mostly aimed downward, strike the ground only to bounce right up to the sky.

Check it out. Look in the direction of your nearest big city or town (or overhead if you live in an urban environment) and you'll see a much brighter skyglow than in October. Maybe you'd better buy that nebula filter after all.

Things, however, can always be worse, and I can prove it. During the last three years, I've been teaching an astronomy college course at New York State's only maximum-security prison for women.

It's part of a privately funded program for specially selected, highly motivated inmates who are seeking a college degree. As an astronomy professor, I was happy to accept this new teaching experience, but I immediately confronted unique obstacles.

The warden did finally grant permission for the 18 women to accompany me to the prison yard at night for some outdoor observing as part of the course. I was even allowed to carry a heavy clock-driven Schmidt-Cassegrain through the various sliding steel doors and checkpoints, where it was viewed with extreme suspicion by every passing guard. ("Cuts through steel like butter," I quipped once before realizing that humor was a no-no.) Finally, only one major problem remained: lights.

You think you have light pollution near your home? Be assured it is nothing compared to the glare enveloping a maximum-security prison. I didn't bother asking if they would dim them on Thursday nights. Although most of the course involved classroom time for learning things like Kepler's Laws, I felt that for these women the time among the stars would be the highlight of the whole semester.

Purchasing a giant one-million candlepower spotlight that I correctly assumed would overpower the everpresent lights, I used its dazzling narrow beam as a planetarium-like pointer for star and constellation identification. (Given the ultratight security, that superbrilliant parabolic lantern proved the trickiest item to get permission to bring inside. I finally got the go-ahead when I asked the top security officer how a 2 million-candlepower spotlight could possibly be useful in an escape.)

Yes, the class was confined to exploring celestial wonders that are immune to extreme light pollution — but that's no small inventory. Every backyard amateur should follow the lead of seasoned astronomers who have memorized a similar valuable list of bummer-proof things-to-see (like planets, variables, and bright binaries) during major skyglow periods, like the current month.

Limited to the 300 stars brighter than 3rd magnitude and working around the annoying protrusions of guard towers and such, we nonetheless soared through the cosmos. The women gasped at lunar craters through the 5-inch Schmidt. They stared in disbelief at Saturn's rings. They clearly saw the colors of Albireo and understood why hot stars are blue. They easily split Epsilon Lyrae and Theta Orionis into wonderful quadruple suns. They saw the dance of Jupiter's moons, the duplicity of Polaris and Rigel, the uncommon brilliance of Venus.

They learned how, from their cells each dawn, they could make sense of the ancient changing positions of the sunrise. Time, the one abundant commodity in their lives, could now be measured by immense distant spheres that — like them — mark the years in slow motion.

During each of those four-month courses, several would express deep remorse for what they had done. I knew that many of these women had still to serve more than 20 years of their sentences; I hoped they would finish earning their degrees and perhaps someday put them to good use. I also hoped that the Law of Bummers would eventually cut them a break. And now, in February, when skies are at their nadir for most of us, my ongoing prison nights remind me that regardless of sky, season or personal circumstance, the heavens always place something special in view. ■

Bob Berman regularly writes Astronomy's *Strange Universe column.*

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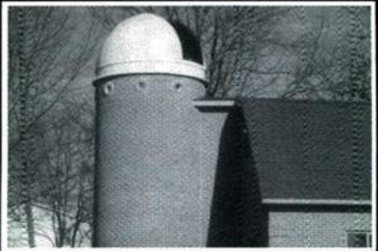

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Michael Klensch

This spectacular auroral display was captured over the Saw-Tooth Range near Skagway, Alaska.

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All-India Amateur Astronomers' Meet
PRL Auditorium, Gujarat University, Ahmedabad, India. Hosted by the Astronomy Club Ahmedabad. For more information, visit the website, http://www.astronomyclub.freeservers.com.

JANUARY 29
Dean Lecture Series — Alexander Vilenkin, The Cosmological Constant
Morrison Planetarium, California Academy of Sciences located in Golden Gate Park, San Francisco, California. 7:30 P.M. Tickets are $3; advance purchase recommended. Contact (415) 750–7127; website, http://www.calacademy.org/planetarium.

FEBRUARY 10–16
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Cedar Key, Florida. Sponsored by National Public Observatory, Cedar Key Area Chamber Of Commerce, Florida Fish and Wildlife Conservation Commission and Florida Park Service. All events are free, but registration for slide show is required. For more information, call Cedar Key Scrub State Reserve (352) 543-5600; email bemusabord@aol.com; website, http://members.aol.com/bemusabord/cedarkey.html. For accomodation information, call (800) FLA-KEYS.

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Winter Star Party
Camp Wesumkee, West Summerland Key, Florida Keys, Florida. Sponsored by the Southern Cross Astronomical Society. Advance registration is required. For more information, contact registrars Fred and Lucille Heinrich, 6165 Wiggins Road, Live Oak, FL 32060; (904) 362–5995; fax, (904) 362–5996; e-mail, heinrich@atlantic.net; website, http://www.scas.org.

FEBRUARY 12 & MARCH 12
Free Planetarium Show
Gary E. Sampson Planetarium, Wauwatosa West High School, Wauwatosa, Wisconsin. 7 P.M. Seating is limited. For reservations call (414) 773–3007. The free, one-hour shows will take place on the second Tuesday of every month throughout the school year. For more information, contact Mary Pat Pfeil, (414) 773–1022.

FEBRUARY 13–17
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Hickory Hill Observing Complex, 10 miles S.E. of Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club. For information, see website, http://home1.gte.net/hoffmanc/index.html or contact chairpersons Dennis or Ellen Farr, 19309 Eastbrook Dr., Odessa, FL 33556; (813) 792–0721; e-mail, Dnefarr@aol.com.

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MARCH 3

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MARCH 4–8

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MARCH 21

Astronomy Lecture — Ancient Astronomies-Ancient Worlds

Universe Theater, Adler Planetarium and Astronomy Museum, Chicago, Illinois. 7 P.M. Clive Ruggles of the University of Leicester, England, will explore the variety of ways humans have come to terms with what they perceive in the skies, using examples from the Stone Age to the present. Key questions and issues facing modern-day archaeoastronomy and ethnoastronomy will be addressed. Arrive early to join Adler at 6 P.M. for a guided tour of the Cultural Astronomy Gallery's new exhibit, "Bringing the Heavens to Earth." For more information, contact (312) 922-STAR; or view Adler's website, http://www.adlerplanetarium.org. A

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Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to jmcgovern@astronomy.com. Look for additional events at http://www.astronomy.com.

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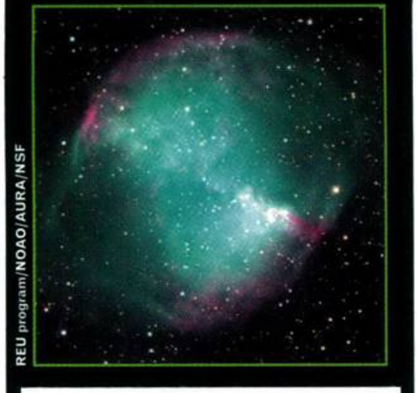

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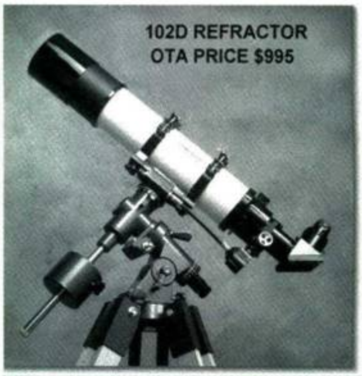

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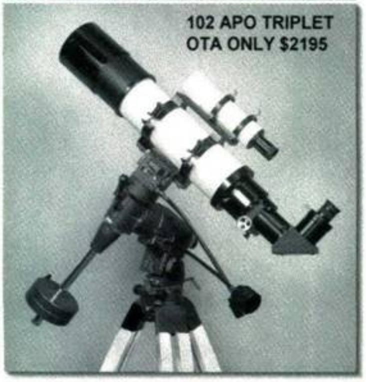

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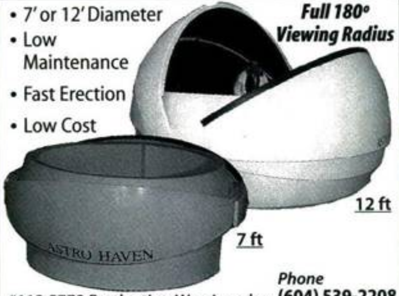

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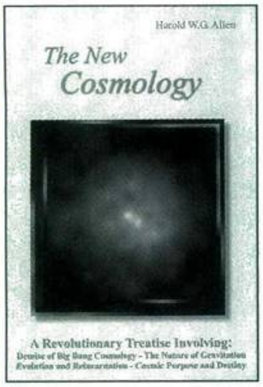
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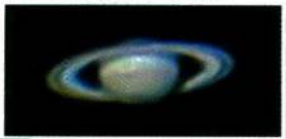

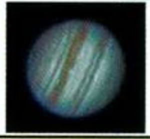

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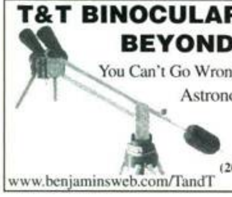

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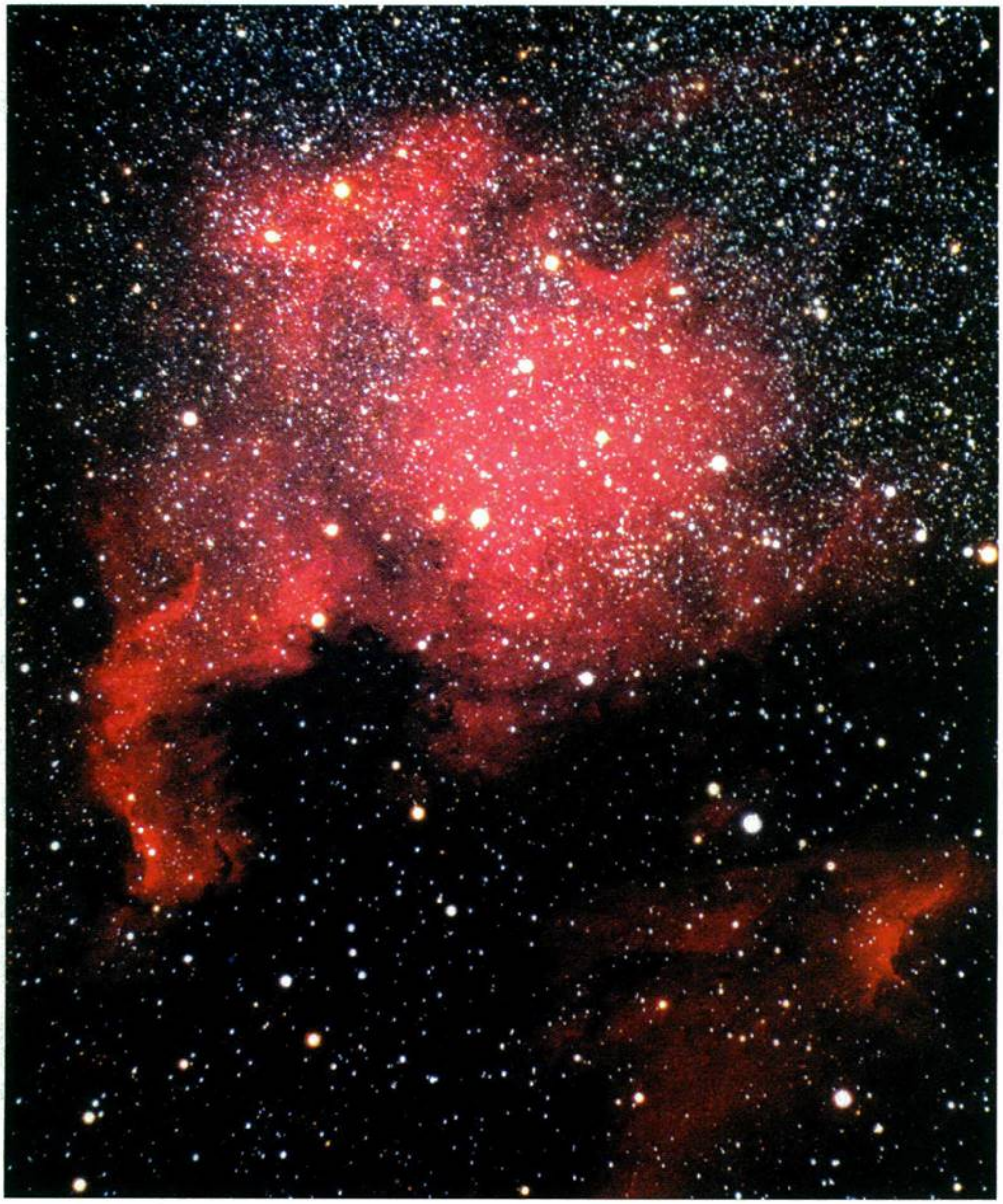
High-Altitude Galaxies

▶ Have you ever pulled an all-nighter, observing for hours with no food, no washroom, and no place to warm up, while lugging heavy scopes and coping with bad skies? As Carol Legate and I recently discovered, all of these heartaches are eliminated at a guest observatory.

Last winter, we decided that we would not suffer deep-sky withdrawal; instead, we decided to go on an astronomy holiday. The two main prerequisites for the destination were simple: clear, dark skies. We concluded that the best choice for our budget and time seemed to be the American Southwest. After surfing the web, our trip was booked. New Mexico, here we come!

We arrived for the February dark of the moon at beautiful Star Hill Inn near Sapello. The private observatory complex is located in the east foothills of the Rocky Mountains in northern New Mexico, where dark skies are a preserved heritage. New Mexico just passed a statewide ordinance protecting its skies for future stargazers.

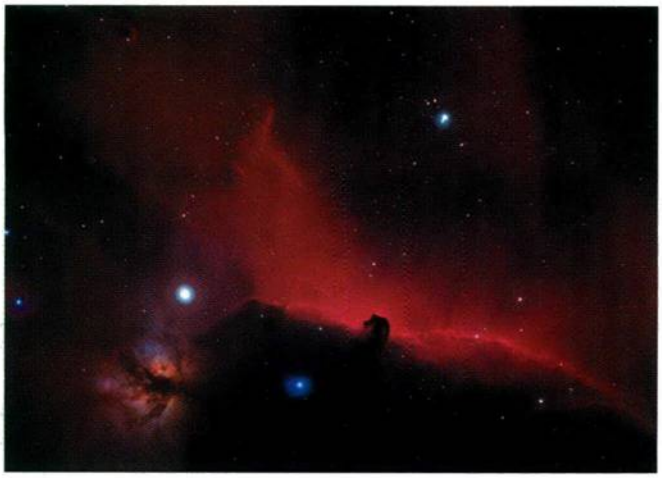
The beautiful natural setting of the observing area soothes the mind. Carol rented a 22-inch Dobsonian and I took the wheel of a go-to 14-inch SCT for the next four nights. At an altitude of over 7,200 feet, we peered through two kilometers less atmosphere than usual. The sky was transparent.



The North America Nebula

GIANNI TUMINO AND MELANIA PLUCHINOTTA

(3-inch refractor at f/5.9, Kodak E-200 slide film, composite of two 30-minute exposures)



The Horsehead Nebula

WILLIAM MCLAUGHLIN

(5-inch refractor at f/5.9, Ektachrome 200 film, composite image)

Although our second night was partly clouded out, Carol still star-hopped to 29 clusters located just in the bucket of the Big Dipper. By the fourth night, she had demolished several pages of Wil Tirion's star charts, and by the end of that night, she had observed and documented 240 galaxies. The last night ended as we watched the summer Milky Way float over the top of an orange sliver of morning twilight.

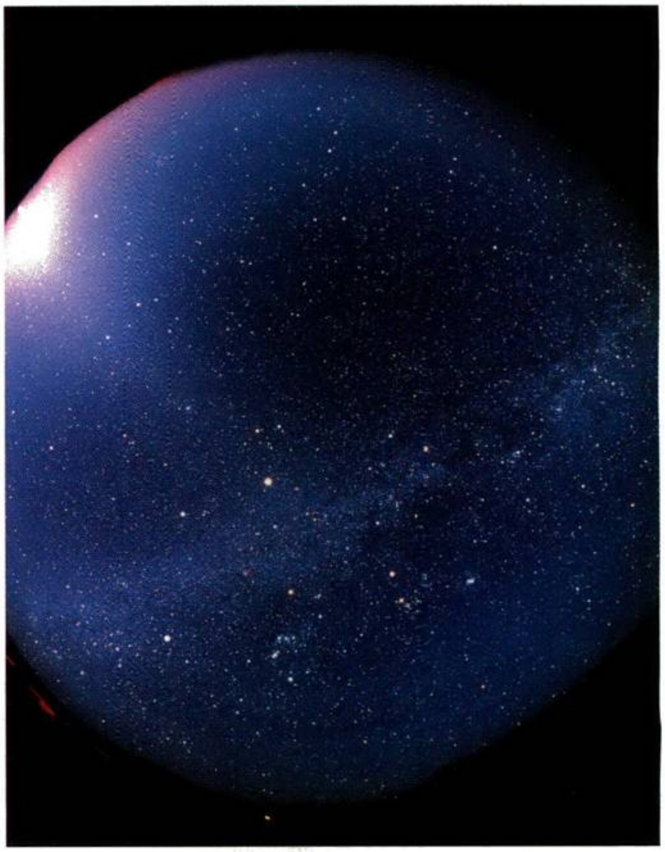
With our minds filled with starlight, we headed off to Chaco Canyon. Chaco was the largest settlement of the ancient Anasazi Indians in the Southwest. They built an advanced culture, leaving signs in the ruins that they were skilled stargazers.

Bad weather soon pushed us to southern New Mexico and Cloudcroft, where we stayed two nights at New Mexico Skies Guest Observatory. This is a stunning new facility with the best latest amateur telescope equipment available today. The domes, guest houses and library are located at an altitude of more than 7,500 feet. The area enjoys 280 clear nights a year; would we get one? We did!

This time Carol rented a 25-inch f/4 Dobsonian with crisp optics. She bagged 76 galaxies, for a grand total of 316. We saw everything from 15.5-magnitude objects to clusters of seven galaxies in one eyepiece.

We returned from this adventure feeling like we had traveled light-years through the universe. ■

John Nemy and Carol Legate, founders of The Pacific Observatory in Ontario, Canada, have been showing people the night sky for the past 12 years.



Venus and Zodiacal Light

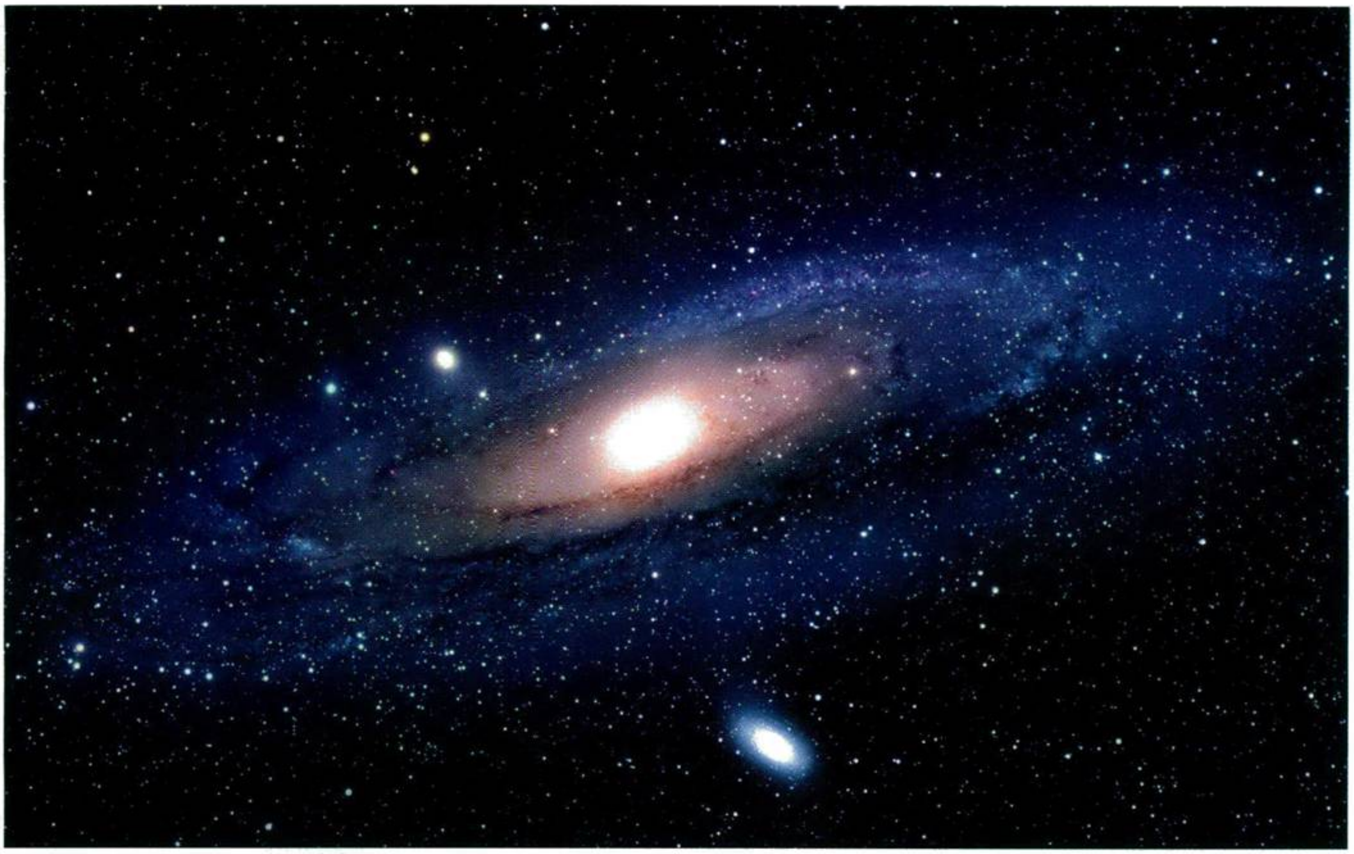
DOUG ZUBENEL

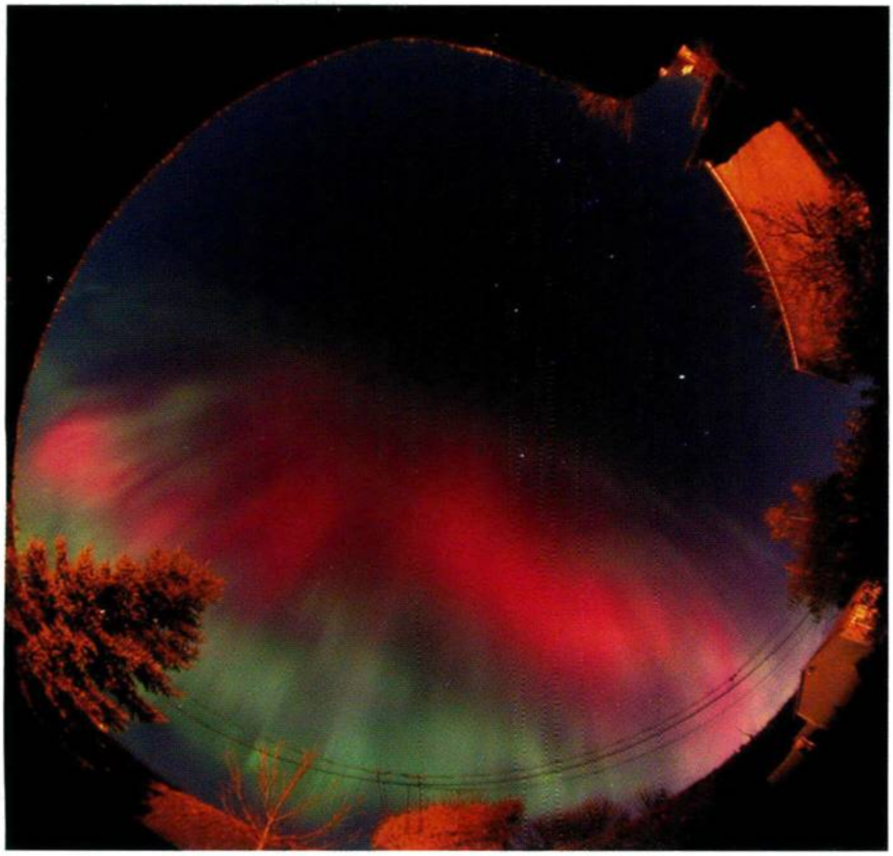
(16mm lens at f/4, Fuji 400 film at ISO 800, 20-minute exposure)

Aurora with Star Trails

MICHEL BENVENUTO

(17mm lens at f/3.5, Kodak Gold 800 film, taken on October 21, 2001, from Nice, France)





The Andromeda Galaxy (M31)

ROB GENDLER

(12.5-inch Ritchey-Chrétien scope at f/5, ST10 CCD camera, composite of six images)

Fisheye View of Aurora

PHILIPPE MOUSSETTE

(Fisheye lens, Coolpix 995 digital camera, 15-second exposure taken October 28, 2001, from Quebec, Canada)

Lunar Meridian Mosaic

JIM THIBERT

(4-inch refractor at f/10.8, six-panel composite mosaic of one-second exposures)

Conjunction of the Moon and Mars

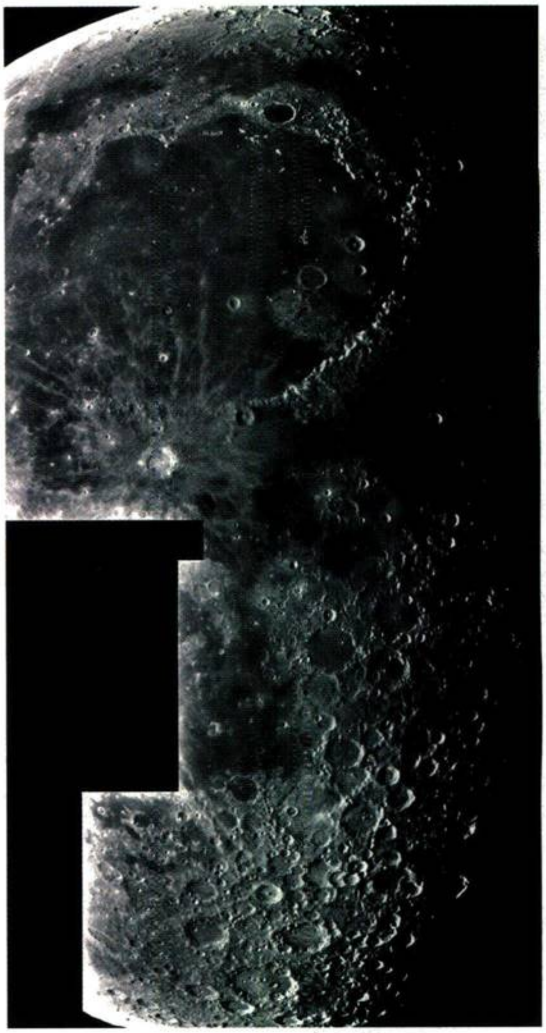
RANDALL WEHLER

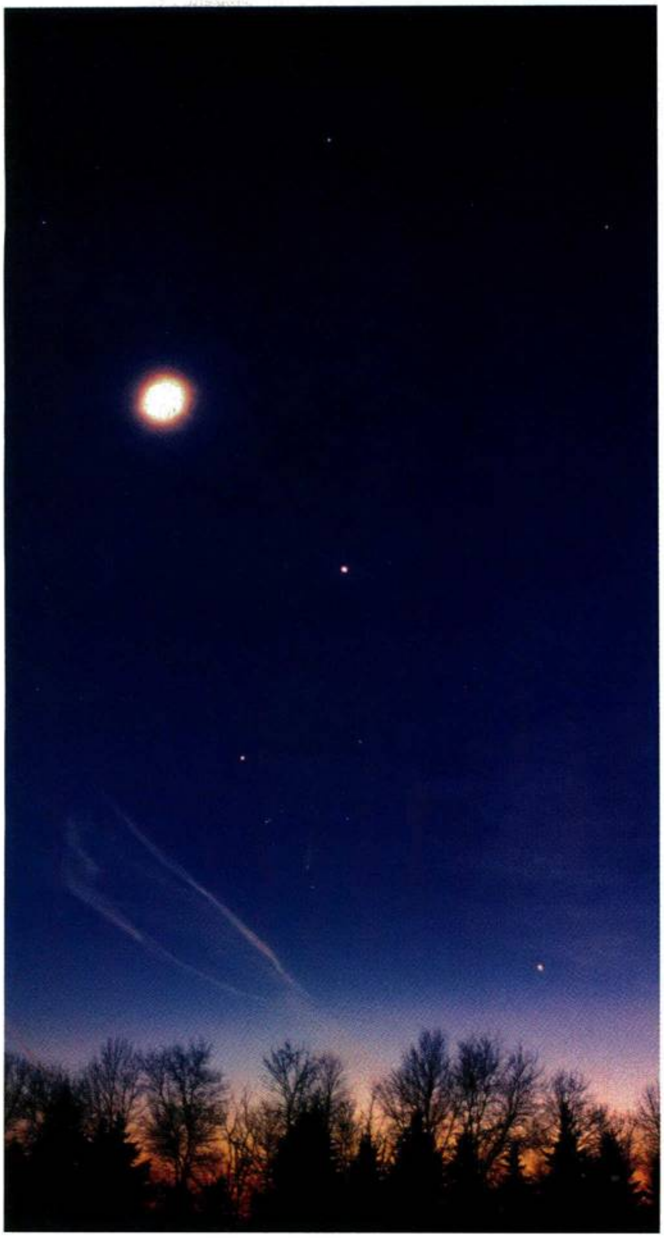
(50mm lens at f/2, five-second exposure taken April 26, 2001)

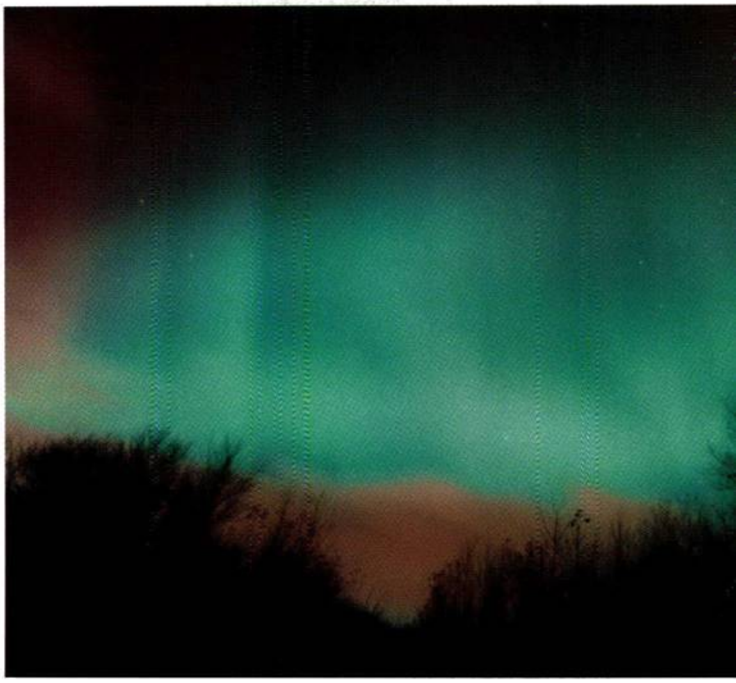
Aurora over Beauport, Quebec, Canada

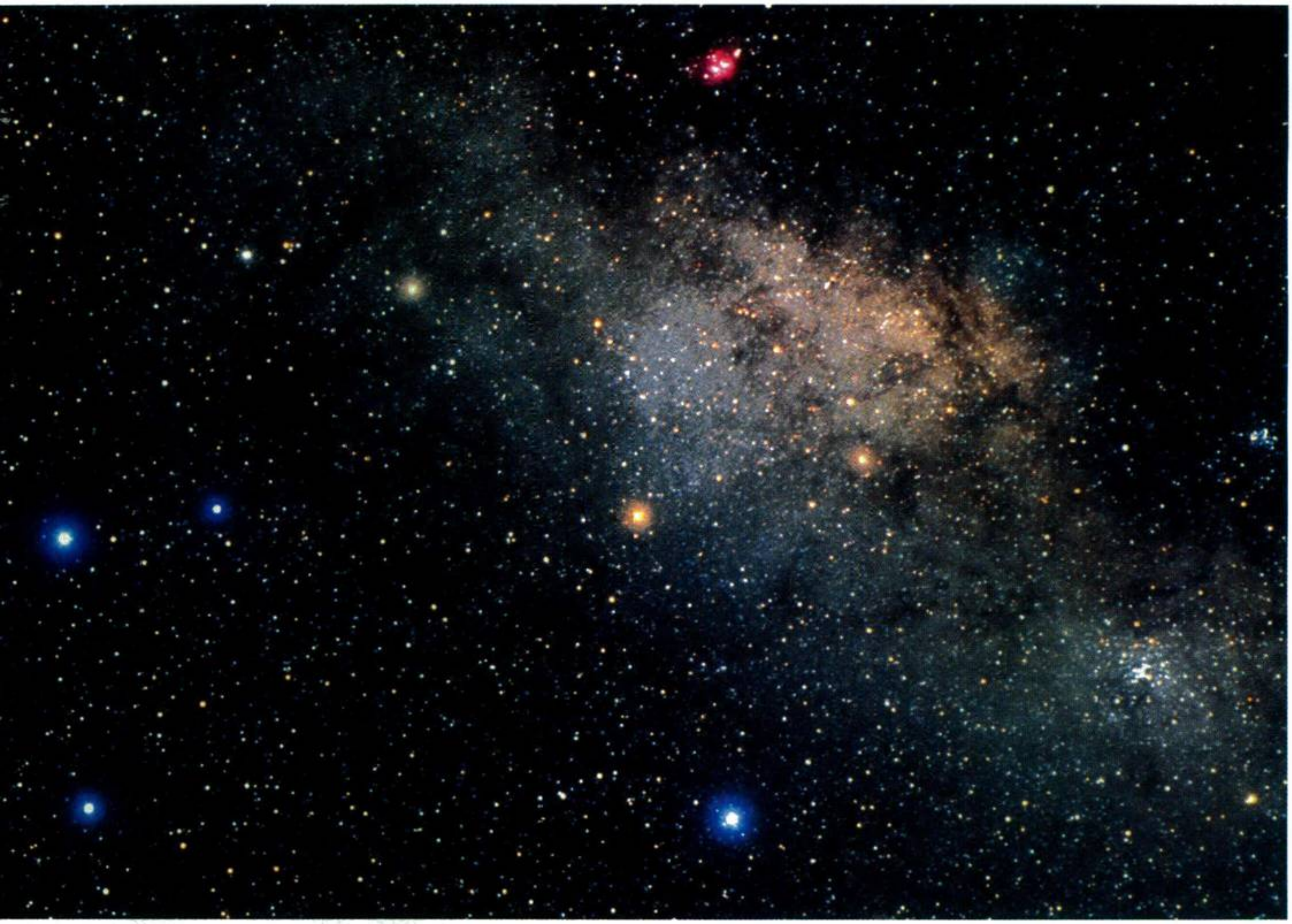
JEAN CHIASSON

(17mm lens at f/3.5, Fuji 800 X-tra film, 25-second exposure taken October 28, 2001)









Sagittarius the Archer

BILL AND SALLY FLETCHER

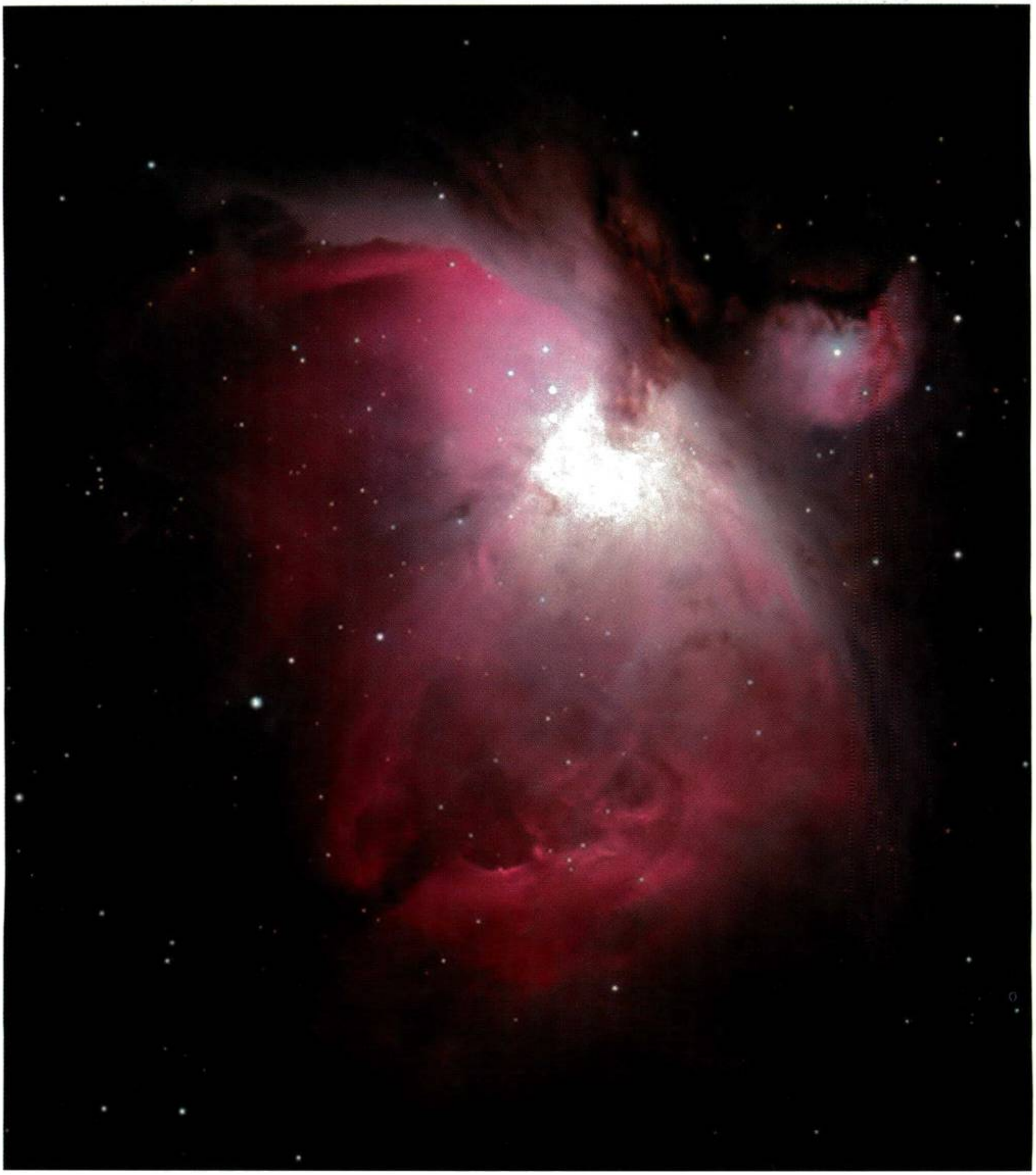
(90mm lens, Kodak Pro 400 PPF camera, composite of two images)

The Brilliant Stars of Orion

JOHN NEMY

(50mm lens at f/3.5, Kodak Slide 200 film, 30-minute exposure)

This month's best astrophoto



The Orion Nebula (M42)

WILLIAM MCLAUGHLIN

(12.5-inch Ritchey-Chrétien scope at f/9, Finger Lakes Dream Machine CCD camera, composite of four images)

The large emission nebula in Orion showcases one of the greatest nearby star factories in our Milky Way Galaxy.

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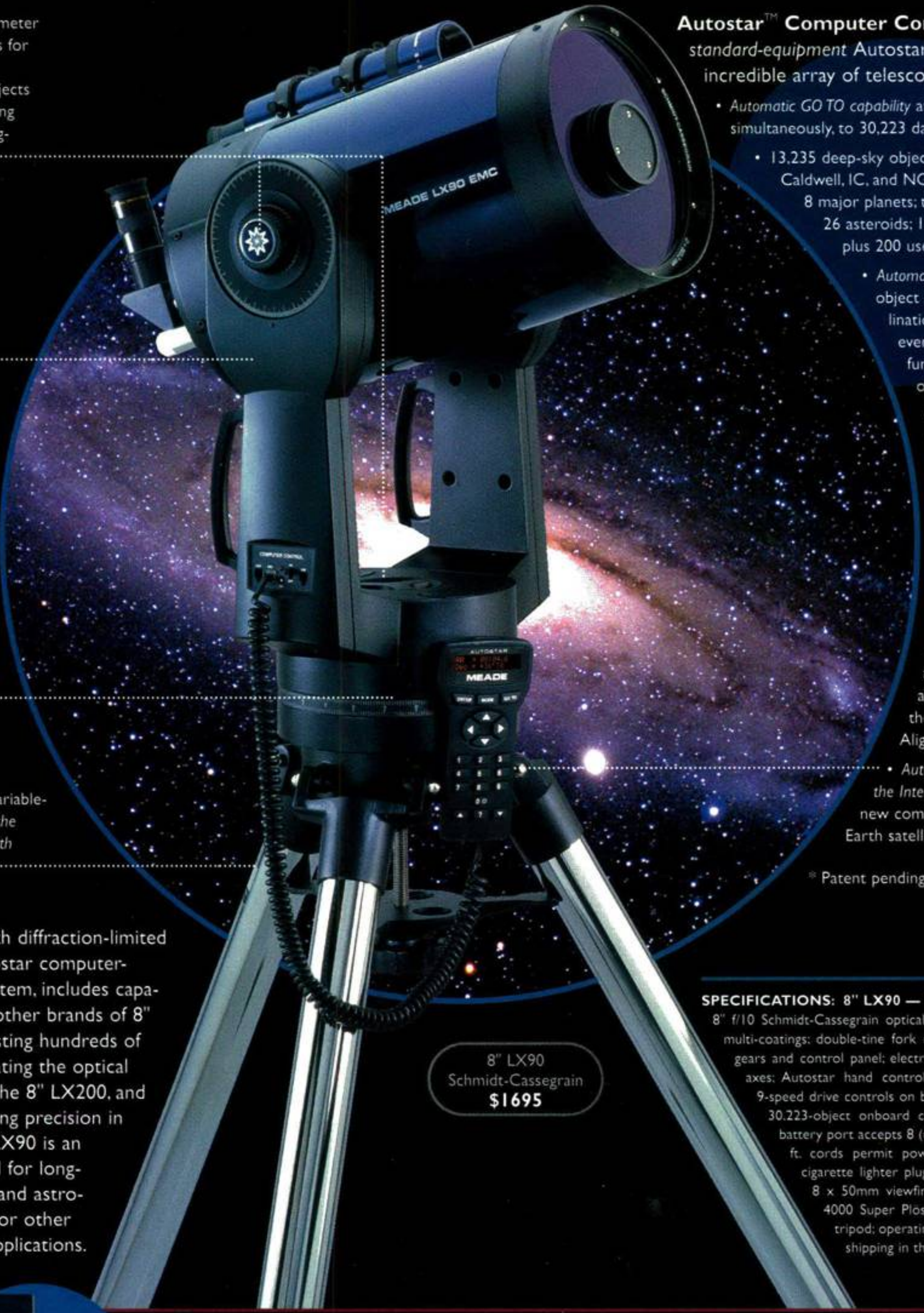

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